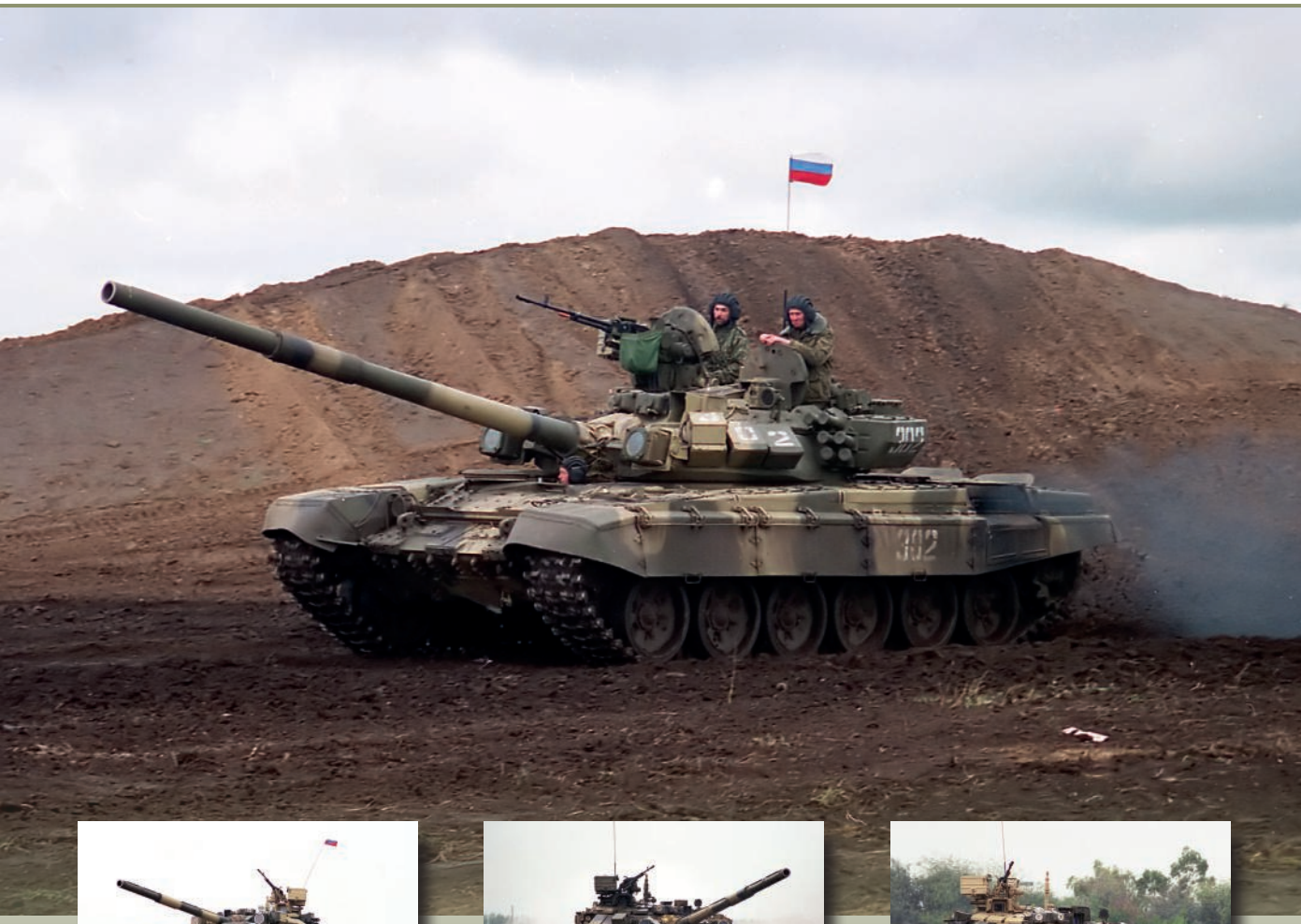
T-90 STANDARD TANK

The First Tank of the New Russia



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NEW VANGUARD 255

T-90 STANDARD TANK

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T-90 STANDARD TANK

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INTRODUCTION

The T-90 was the first mass-produced tank in Russia following the 1991 collapse of the Soviet Union. It has become the most widely manufactured tank of the post-Cold War era, with about 2,700 ordered over the past 25 years.

In spite of its name, the T-90 is an evolutionary development of the earlier T-72 series. In the late 1980s, the Soviet Union had three standard tanks (*osnovnoy tank*) in production, Kharkov's T-64, Leningrad's T-80, and Nizhni-Tagil's T-72. All three tanks had very similar technical characteristics and the same main armament, yet all posed their own logistics burden since they had different engines and suspension. The simultaneous manufacture of the "triplet" tanks was a reflection of the decay in Soviet defense policy in the face of regional industrial politics.[1] One later Russian history labeled this unfortunate situation "a crime against the Soviet Army."

Of the three tanks in production, the T-72 was regarded as a "mobilization tank," that is, an inexpensive design that in the event of war could be churned out in large numbers at low cost. This was especially evident in its fire-control system, which was a generation behind its two contemporaries. The fire-control system on modern tanks is the single most expensive sub-assembly due to the incorporation of advanced night vision sensors and fire-control computers. The T-72 was also the only one of the three tanks that was license-produced outside the Soviet Union. Total production of the T-72 in the Soviet Union from 1973 to 1990 was 22,096 tanks.

The imposition of the "defense sufficiency" doctrine in the Gorbachev years led to substantial reductions in Soviet tank production. The Soviet Union had five tank plants in 1980 but only three remained active by 1991. After the Soviet collapse, only two remained inside the Russian Federation. Annual tank production plummeted from 3,254 in 1987 to 1,000 in 1991 and fell rapidly after that. The Kharkov tank plant, long considered the premier Soviet tank design and production center, had produced 800 T-80UD tanks in 1991. Since it was located in Ukraine, the Kharkov plant was cut off from the Russian Federation. T-80U production in St Petersburg at the

1 The political complexities of the Soviet tank industry in the 1980s is covered in more detail in previous books in this series including: Steven Zaloga, *T-64 Battle Tank: The Cold War's Most Secret Tank*, Osprey New Vanguard 223 (2015) and *T-80 Standard Tank: The Soviet Army's Last Armored Champion*, Osprey New Vanguard 152 (2009).

Production of the Soviet Triplet Tanks 1969–1990				
	T-64	**T-72**	**T-80**	**Total**
1969–72	1,560	–	–	1,560
1973	500	30	–	530
1974	600	220	–	820
1975	700	700	–	1,400
1976	733	1,017	30	1,780
1977	875	1,150	40	2,065
1978	902	1,200	53	2,155
1979	910	1,360	80	2,350
1980	910	1,350	160	2,420
1981	910	1,445	278	2,633
1982	910	1,421	400	2,731
1983	880	1,520	540	2,940
1984	825	1,651	670	3,146
1985	633	1,759	770	3,162
1986	660	1,745	840	3,245
1987	600	1,794	860	3,254
1988	–	1,810	1005	2,815
1989	–	1,148	710	1,858
1990		776	630	1,406
Total	**13,108**	**22,096**	**7,066**	**42,270**

Leningrad Kirov Plant ceased in 1990 prior to the Soviet collapse. T-72 production at the Chelyabinsk Tractor Plant (ChTZ) had ceased in 1989 after 1,522 had been built there. This left only two functioning tank plants in Russia, the Uralvagonzavod (UVZ: Ural Rail-Car Plant) in Nizhni-Tagil and the Transmash plant in Omsk in Siberia. Of these two, the UVZ in Nizhni-Tagil was the more significant. It included both a substantial design bureau, nicknamed the "Vagonka," as well as a large manufacturing facility. It had been responsible for the design of several Soviet tanks during the Cold War years including the T-55, T-62 and T-72. The Omsk plant had a very small design staff and was regarded as a subsidiary plant, usually manufacturing tanks developed at other locations. At the time of the Soviet collapse, the T-80U was still in production at the Transmash Plant in Omsk while T-72 was in production at UVZ in Nizhni-Tagil.

In 1992, the Russian defense ministry made it clear that it could no longer afford to simultaneously buy two main battle tanks. Russian officials stated that they wished to cut production down to a single type, either the T-72 or the T-80. However, selecting one or the other tank meant that economic catastrophe would befall the losing city. Therefore, Russian officials continued to order both types in small amounts. In 1992, the Russian Army ordered only 20 tanks: 5 T-80U tanks from Omsk and 15 tanks from Nizhni-Tagil. Tank production at Omsk and Nizhni-Tagil in 1992–93 was well beyond the puny state orders due to some export orders, but only a pale shadow of the 1980s. This additional production was not ordered by the Russian Army, but undertaken simply to keep the plants from closing. There was the hope that large export orders would emerge to save the plants and sop up this surplus. However the anticipated export orders did not materialize. The UVZ in Nizhni-Tagil had about 350 T-72S and T-90 tanks in its factory yards, and Omsk had 150–200 T-80U tanks. Some of these T-80U tanks

A T-90 on display in the Siberian Military District in 1997 near Omsk at the base of the 242nd Training Center of the VDV Airborne Assault Force. The early T-90 can be distinguished from the earlier T-72B series by the use of the two Shtora dazzlers on either side of the main gun.

were exported to Cyprus and South Korea in 1996; UVZ gradually exported the T-72 tanks. Lack of pay at the Nizhni-Tagil plant led to strikes in July 1995 during which the workers seized several of the idle tanks and drove them through the city in protest.

T-72 BECOMES T-90

The T-72 tank had been accepted for Soviet army service in August 1973. The basic design had undergone evolutionary improvements at UVZ in Nizhni-Tagil. By the late 1980s, the standard production type was the T-72B (Obiekt 184) that had entered mass production in 1985. The next step at UVZ was a parallel effort to examine an entirely new tank design, the Obiekt 187, alongside a substantially modernized T-72B, called the Obiekt 188.

The Obiekt 187 started with a clean slate and was managed by deputy chief designer A. S. Shchelgachev. The design of a completely new tank had not been authorized by the Kremlin and was largely the result of the local initiatives of the Nizhni-Tagil plant. It was funded under the same program as the Obiekt 188. The hull design was significantly larger than the T-72 to permit the use of a larger engine. The first two prototypes were quite similar to the Obiekt 188 in many respects, including the use of an 840hp V-84 diesel engine and a cast turret. The third and fourth prototypes laid the groundwork for the intended configuration with a new welded turret as well as much more powerful engines, the GTD-1500 gas turbine or the 1,200hp Chelyabinsk A-85-2 diesel engine. The fifth and sixth prototypes were intended to serve as the patterns for eventual serial production. The armament on the Obiekt 187 was the new 2A66 125mm gun developed at artillery plant No. 9 in Sverdlovsk (now Yekaterinberg). Although this gun could employ the same 125mm ammunition used in the existing Soviet D-81T 125mm tank guns, it used improved construction that permitted

higher bore pressures. Development of the 2A66 gun was accompanied by the development of a new family of 125mm tank gun ammunition. One of the main limitations of the existing tanks was the height of the autoloaders. This limited the length of the long-rod penetrators used in their APFSDS (armor-piercing, fin-stabilized, discarding-sabot) projectile. To improve armor penetration, a longer penetrator was necessary as well as a new autoloader that could accommodate the lengthened ammunition, and this was developed as the 3BM39 Anker. Fire control was based on the 1A45 Irtysh system as on the Obiekt 188. The Obiekt 187 used a next-generation reactive armor codenamed Malakhit along with improved laminate armor in the hull and turret.

Design of the Obiekt 188 was formally initiated by a decree of the Council of Ministers of the USSR on June 19, 1986 and undertaken by the Nizhi-Tagil design bureau under engineer V. N. Venediktov, overseen by the plant's new chief designer, Vladimir Potkin. The original study program was codenamed "OKR Sovershenstvovanie 72B (72B Upgrade)." The core of the new program was to incorporate the 1A45 Irtysh fire-control system of the T-80U tank into the T-72B. In addition, the Obiekt 188 would incorporate the latest in protective technology including a new generation of reactive armor. At the same time, a parallel program was undertaken under the direction of engineer N. A. Molodnyakov to develop an export version of the Obiekt 188, since there was some indication that this type would be superseded in Soviet service by the newer and more advanced Obiekt 187.

The Obiekt 188 was designated initially as T-72BM, the "M" indicating "modernized." The Obiekt 188 incorporated a new generation of reactive armor, designated as Kontakt-5. The most important change in the Obeikt 188 was the incorporation of the 1A45 Irtysh fire-control system from the T-80U. The new fire-control system permitted the use of the 9K119 Refleks guided 125mm projectile, including a fire-on-the-move capability at speeds up to 30 km/h. The fire-control system also permitted the use of the new Aynet high explosive projectile with an air-burst feature. When the air-burst function was selected, the fire-control system monitored the ballistic path of the projectile, and when it passed over the target, it remotely detonated the warhead overhead the target, enhancing its effect against targets such as entrenched troops.

The first four Obiekt 188 prototypes were delivered for state trials in January 1989. Various technical issues were discovered and rectified. The second set of trials involved two improved tanks, and were conducted between June and September 1990. This improved variant was sometimes called T-72BU (*usovershenstvovaniy*: "improved"). Results of the trials were very favorable, and on March 27, 1991, the Russian Ministry of Defense recommended adopting

A T-90 in the Siberian Military District in 1997. Although fitted with the Kontakt-5 reactive armor on the turret side, the standard panels on the front hull side are missing. These are sometimes left off during peacetime training as they hinder access to the suspension during routine maintenance.

the Obiekt 188 tank for army use. The next stage would have been a set of operational trials by army units. At the same time, work on the Obiekt 187 was halted, though the reasons for this cancelation have remained a state secret.

The collapse of the Soviet Union occurred later in 1991, but before the Obiekt 188 entered mass production. The turmoil surrounding the Soviet collapse delayed work on the Obiekt 188 since the issue of state funding was thrown into chaos. To further complicate matters, there had been widespread international attention on the poor combat performance of the T-72 in the hands of Iraqi troops in the 1991 Operation *Desert Storm* conflict. Whether the main fault was the poor training and leadership of the Iraqi Army or inherent problems in the tank's design, the T-72's international reputation had been ruined by the Iraqi debacle.[2] At this time, the T-72 was a staple Soviet export product, and so there was some pressure to rename the Obiekt 188 to distance it from the tarnished reputation of the T-72. The first plan was to change the designation to T-88, a contraction of its internal design codename, Obiekt 188. On June 8, 1992, the new Russian president Boris Yeltsin visited the UVZ plant in Nizhni-Tagil and was shown prototypes of the Obiekt 188. After the visit, Yeltsin agreed to authorize the Obiekt 188 for serial production as the T-88. However, after further discussion, the name was changed again to T-90 to symbolize the fact that it was the first new Russian tank to be built in the 1990s. This was formally adopted in an October 5, 1992 state decree. The export version was designated as T-90S, the S indicating Shchit (Shield).

The first tank of an initial low-rate production batch was ready on September 30, 1992, and by the end of the year 13 T-90 tanks had been assembled. Supply of the Agava-2 thermal imaging sight was a problem due to the low output of the device as well as its extremely high cost. In the event, only two of the original batch of tanks received this sight, the remainder receiving the cheaper Buran-PA night sight. The basic T-90 was followed on the assembly floor in March 1994 by the T-90K command tank. This version had additional radio equipment fitted including the R-163-50 transceiver, a special 4-meter antenna, a navigation aid, and an AB1-P28.5 auxiliary power unit. In general, about 5 percent of Russian tanks were built in the command tank configuration. Total T-90 production in 1992 to 1994 was about 105 tanks.

2 The poor performance of the Iraqi T-72 tanks is detailed in Steven Zaloga, *M1 Abrams vs T-72 Ural: Operation* Desert Storm *1991*, Osprey Duel 18 (2009).

A

1: T-90SA, ALGERIAN PEOPLE'S NATIONAL ARMY, 2016

The color schemes on the Algerian T-90SA vary. Many were delivered in standard Russian three-color camouflage of dark green and gray-yellow with a black disruptive pattern. However, some like this one had a simpler two-color scheme of dark green and gray-yellow without the black disruptive pattern. Tactical markings appear to be minimal.

2: T-90K, 4TH ARMORED DIVISION, SYRIAN ARMY, SIEGE OF ALEPPO, DECEMBER 2016

The T-90 and T-90A delivered to Syria in 2016 came directly from Russian Army stockpiles and so were finished in the usual scheme of dark green and gray-yellow with a black disruptive pattern. This particular tank is so dust covered that the black disruptive pattern is difficult to discern. Many of the Syrian T-90s had simple tactical numbers spray-painted on the side skirts and repeated on the right front dust-guard. These were typically in the pattern 21-#, with numbers as low as 21-4 and as high as 21-22 noted from television footage of the fighting.

1

2

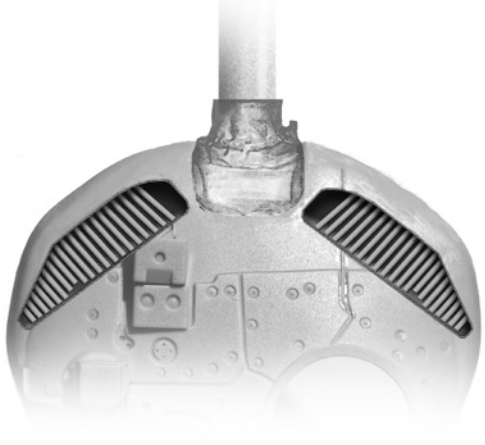
The Decline of the Russian Tank Forces*								
Year	**T-54**	**T-55**	**T-62**	**T-64**	**T-72**	**T-80**	**T-90**	**Total**
1991	1,593	3,130	2,021	3,982	5,092	4,907	0	**20,725**
1992	539	1,266	948	1,038	2,293	3,254	0	**9,338**
1993	515	871	948	705	1,923	3,031	0	**7,993**
1994	394	637	688	625	2,144	3,004	1	**7,493**
1995	5	38	25	161	1,979	3,282	2	**5,492**
1996	5	38	25	161	1,948	3,311	2	**5,490**
1997	1	65	97	186	1,980	3,210	2	**5,541**

*These figures only include tanks deployed in European Russia under the terms of the CFE Conventional Forces in Europe Treaty; 1991 figures for Soviet Army.

T-90 TECHNICAL DESCRIPTION

Protection

The baseline T-90 is fitted with an improved version of the cast turret of the T-72B turret. The turret casting contains a substantial cavity in the front to permit the use of special armor (*spetsbronirovaniya*). This cavity is at a 45-degree angle from the centerline of the tank. This multilayer armor was designed by NII Stali and is estimated to be the equivalent of 530mm of rolled homogenous armor (RHA) against M111 APFSDS (armor-piercing, fin-stabilized, discarding-sabot) ammunition and 520mm of RHA against HEAT (high-explosive antitank) such as the TOW missile warhead. The special armor in the turret cavities was called "reflecting plates" in Russia and NERA (non-energetic reactive armor) among Western specialists. The frontal armor configuration of the cast turret began with an outer layer of about 120mm of cast steel armor. The cavities were about 0.4m wide and 1.1m long and contained twenty special armor modules. Each of these modules was 30mm thick, consisting of a 21mm RHA plate, a 6mm thick rubber sheet, and a 3mm RHA plate. The twenty modules are spaced 22mm apart using simple spacers. Behind the stack of modules was a 45mm RHA plate, followed by the inner wall of the turret casting that was a further 80mm of cast steel armor. At its thickest point, the frontal armor was about 750mm thick. Unlike earlier versions of laminate armor, the modules were elastic and not rigidly fixed by the spacers. When struck, the rubber in the modules would compress and then expand, moving the steel plate back into the path of the incoming penetrator and further degrade its potential penetration. This is the reason that the Russians call this configuration reflective or semi-active armor.



The T-72B and T-90 have a cavity in the front of the turret casting for special laminate armor. This consists of 20 modules in each cavity separated by spacers, as is shown in this computer illustration.

The T-90 is also fitted with an appliqué of Kontakt-5 explosive reactive armor to the outside of the turret, also developed by NII Stali. This is called universal reactive armor (UDZ) since it degrades the performance of both APFSDS and HEAT warheads in contrast with the first generation of Kontakt reactive armor, which degraded only HEAT warheads. This required the use of a steel plate 4 to 10 times heavier than used in the first-generation Kontakt in order to interfere with the APFSDS projectile. It also required the replacement of the

older 4S20 explosive module with the new 4S22 module. The first-generation 4S20 explosive module was designed to be insensitive to kinetic impacts such as small-arms fire, while the 4S22 was designed so that when the APFSDS projectile struck the outer metal plate, the impact would generate high-velocity fragments sufficient to detonate its explosive panel. The 4S22 explosive modules each contain about 0.3kg of plastic explosive that propel the outer steel plate into the path of the enemy projectile once detonated. The high-hardness steel boxes of the Kontakt 5 system contain multiple 4S22 modules. For example, the turret panels contain three 4S22 modules, one layer thick. According to NII Stali, the Kontakt-5 appliqué offers a 34–57 percent increase in protection beyond the baseline armor at a very modest weight cost of about 3 metric tons. In the late 1990s, the US Army conducted firing trials against 12 T-72B1 tanks protected with special armor and Kontakt-5 reactive armor. The tests found that the tank could not be penetrated frontally by the best Cold War US kinetic round, the 120mm M829A1 depleted-uranium APFSDS.

The T-90 at IDEX-97 demonstrated the Shtora missile dazzlers during the mobility demonstrations. The Shtora dazzler adjacent to the gun barrel can be seen illuminated in this view.

Another innovation on Obiekt 188 was the use of the TShU-1 Shtora (curtain) antimissile protection system. The Shtora system had originally been fitted to the T-80UK tanks, and its use on the T-90 was another sign of the shift of this type from low-cost to high-tech status. The Shtora system was designed by SKB Rotor, the design bureau of the Elektromashina electronics factory in Chelyabinsk. It was intended to defeat antitank missiles and guided projectiles. The most obvious element of the system was a pair of TShU-1-7 infrared dazzlers fitted on either side of the main gun barrel. Typical NATO antitank missiles such as TOW, HOT, and Milan used SACLOS (semi-active command-to-line-of-sight) guidance. The antitank missile had an infrared flare pointing backwards. Once the missile was launched, a tracker on the missile launcher locked on to the flare and guided the missile by correlating the location of the flare to the location of the target. The dazzlers of the

This is a close-up of the TShU-1-7 infrared dazzler of the Shtora antimissile system in operating mode with its armored cover removed. The two devices above the gun barrel are the precision detectors of the Shtora's anti-laser system.

Shtora system were intended to disrupt the guidance sequence by confusing the missile tracker, since its own infrared beam was stronger than flare on the missile. The TShU-1-7 dazzler projects a beam 4 degrees in elevation and 20 degrees in azimuth. The light intensity is 20 millicandela.

The second element of the Shtora system was intended to deal with missiles or guided munitions using SAL guidance (semi-active laser) such as the US Army's 155mm Copperhead guided artillery projectile, or the early versions of the AGM-114 Hellfire antitank missile. Four laser detectors were mounted around the periphery of the turret. This consisted of two precision detectors immediately in front of the turret and two coarse detectors covering the sides and rear of the tank. When switched on, the detectors fed data to a control unit inside the tank, which could automatically activate the Tucha Type 902 smoke system. This was a cluster of six smoke grenade launchers on both sides of the turret that fired the 3D17 smoke grenades. The smoke grenade detonated about 80 meters from the tank, covering a swath about 45 degrees on either side of the tank with the smoke lasting up to an hour depending on wind conditions. The special anti-laser spectral smoke emitted by the grenade was designed to block laser beams in the 0.4 to 14.0 micron wavelength, the typical range of military laser designators at this time. The Shtora manufacturer claimed that the dazzler would reduce the hit probability of SACLOS antitank missiles by 3 to 5 times, and that the smoke system would decrease the hit probability of laser-guided projectiles by 1.5 times.

Firepower

The T-90 uses the 2A46M-1 125mm smoothbore gun, also known by its bureau designation of D-81TM. This gun was developed by the Spetstekhnika design bureau in Ekaterinburg (Sverdlovsk), and manufactured at the Motovilikha artillery plant in neighboring Perm. Motovilikha claimed that the new 2A46M1 tank gun offered 20–25 percent increased accuracy compared to earlier models of the 2A46. It was followed by the 2A46M-2 version that has a replaceable chromium barrel liner, an attempt to improve the short barrel life of previous tank gun tubes.

One of the most important improvements in the new version of the gun was a new generation of 125mm ammunition, developed by NIMI (Mechanical Engineering Research Institute) in Moscow. The APFSDS round is the 3VBM17 Mango round, which included the 3BM42 tungsten carbide projectile; it has a stated armor penetration (at a range of 1000 meters at 60 degrees) of over 250mm. The standard HEAT round in the late 1980s was the 3VBK16 with the 3BK18M projectile; it has a stated penetration of 260mm and used a conventional copper cone. This was followed by two new HEAT rounds. The 3VBK17 with its 3BK21B projectile used a depleted uranium cone liner and had a maximum penetration of about 705mm. The multicharge 3BK29 projectile used a small precursor charge to strip off any

This shows the gunner's controls in a T-90, with the main 1G46 fire-control system on the right. This system includes the tank's laser rangefinder. The sight on the left is the TPN-4-49 Buran-PA thermal imaging night sight.

reactive armor and offered penetration of over 350mm plus any reactive armor layer. The common high-explosive fragmentation round around 1990 was the 3VOF36 round with the 3OF26 projectile.

The most critical advance in the T-90 over the T-72B was the adoption of the 1A45T Irtysh fire-control system as used previously on the T-80U. Unlike most Western integrated tank fire-control systems, the Russian system divides the gunner's fire-control systems into two blocks, the periscopic gunner's night sight immediately in front of the gunner's hatch, and the integrated gunner's 1A43 day sight with 1G46 laser range-finder/missile laser guidance system on the forward part of the turret, integrated with the 1V528-1 digital ballistic computer.

In comparison to NATO tanks, Russian tanks of the early 1990s suffered from the slow arrival of thermal imaging gunner's night sights. Thermal imaging sights required cryogenic cooling and an advanced focal-place array that posed mass production difficulties and a substantial increase in cost over the previous generation of image-intensification night sights. A thermal imaging sight in this era could easily add a quarter-million dollars to the cost of the tank. Ideally, the Russian Army would have preferred to adopt the T-01-P02T Agava-2 thermal imaging sight on the T-90, but cost and manufacturing hurdles meant that most T-90s were fitted with the T01-K01 Buran night vision system that used the TPN-4-49-23 Buran-PA image intensification sight. The T-90 with the Buran-PA sight were known as Obiekt 188B, those with the Agava as Obiekt 188B1.

These are three of the common 125mm antiarmor projectiles developed in the 1980s and widely exported over the past decade. From left to right are the 3BK18M projectile of the 3VBK16 HEAT round, the 3OF36 projectile of the 3VOF36 high explosive round and the 3BM42 projectile of the 3VBM17 "Mango" APFSDS round. The APFDS round contains additional propellant in the projectile casing, as is seen here.

The new fire-control system allows the T-90 to employ the 9K119 Refleks guided 125mm projectile. The earlier T-72 variants had been fitted with the related 9K120 Svir, which had less range, 4km vs 5km. The Refleks was used in conjunction with the 9S515 missile-control system, part of the T-90's 1A45T fire-control system. The Refleks was based around the 3UBK14 ammunition that consisted of a 9M119 missile and a 9Kh949 reduced-charge propellant casing with a spacer plug, which seated the missile properly into the tank's gun. The 3UBK14 ammunition fits into the normal autoloader on the tank, like any other round of 125mm ammunition. After launch, two sets of fins pop out, one for stability and the other for steering. The body of the 9M119 projectile contains an advanced 4.2kg shaped-charge warhead with a penetration-to-diameter ratio of about 7:1, and a penetration advertised as 650–700mm.

After being fired, the Refleks missile drops a small cover over the tail of the missile, which protects the rear-ward pointing optical window. The T-90's fire-control system includes a laser emitter that creates a laser "funnel" with the missile riding in the center. The frequency of the beam is modulated in different sectors around the projected funnel so that if the missile deviates from the center, the guidance system onboard the missile interprets the signal and makes flight corrections to move it back into the center of the beam. The guidance system uses a timer so that the laser funnel is periodically altered in diameter so that, to the missile, it retains a near-constant diameter. Russian literature

The T-90 can fire a variety of 125mm guided projectiles. The two guided rounds shown here are the high-explosive 9M119F1 with thermobaric warhead on the right and the antiarmor 9M119M1 Invar-M on the left, both produced by the Degtyarëv plant in Kovrov.

stated that the Refleks had an 80 percent probability of hit at 5000m. The list price per round in the early 1990s was $40,000, which limited the distribution of the missile to an average of 4 per tank.

Another armament change between the T-72B and T-90 was the adoption of a remotely-controlled weapon station for the commander, based on the type used with the T-80. This was armed with a remotely-controlled NSVT Utes 12.7mm machine gun with the PZU-7 sight and ETs29 stabilized fire-control system. The new commander's cupola included a substantially improved vision system with the T01-K04 vision system including a TKN-4S Agat-S image intensification day/night sight.

Mobility

The T-90 was powered by the V-84MS multifuel diesel engine, an upgrade of the V-84-1 used on the T-72B. This offered the same power output of 840hp (618 kW) even though the T-90 weighed over two tons more than the T-72B. To compensate for the heavier weight, the T-90 was fitted with improved torsion bars. As a result, the T-90 was more sluggish than either the T-72B or the T-80U. Although the T-90 had poorer power-to-weight ratios than the T-80U, the engine was significantly more reliable than the gas-turbine engine on the T-80U, and it also offered significantly lower fuel consumption.

B

1: T-90, OMSK HIGHER TANK ENGINEER ACADEMY, OMSK, SIBERIA, 1995

Tank camouflage in the Russian Army is the responsibility of the 15th Central Research-Testing Institute of the Engineer Force (15-m TsNIIIV). In the late 1980s, the Soviet Army began to adopt a factory-applied three-color disruptive camouflage scheme closely resembling the US Army MERDC scheme. The colors consisted of the usual dark camouflage green (KhS-5146), with a pattern of gray-yellow (*sero-zheltiy* KhS-5146) with black crow's feet (*cherniy* KhS-5146). These schemes remained common through the 1990s and were not formally terminated in Russia until April 2013. Tactical markings seen here follow the usual Russian practice of a three-digit number. Typically, these indicate battalion, company, tank, but the system is not rigidly applied and can have other meanings such as the first number indicating the company and the final two numbers as a sequential numbering of the tanks within a battalion.

2: T-90A, 1ST MOTOR RIFLE REGIMENT, 2ND GUARDS TAMANSKAYA MOTOR RIFLE DIVISION, MOSCOW, 2015

On April 4, 2013, the defense minister Sergei Shoigu announced that the army would revert to the use of an overall single-color camouflage finish of either dark green, light green or sand in place of the previous three-color scheme. This was done in part to economize on paint but also due to the view that painted camouflage is less useful than other forms of camouflage such as the Nakidka multispectral camouflage system. The predominant factory color for the Russian Army is the usual camouflage dark green.

Vehicles on display in recent Moscow Red Square parades have carried a distinctive decorative marking, as seen here. The orange and black elements of the parade insignia are based on the traditional ribbons of the Order of St George (*Orden Sviatogo Georgia*) that had been abolished in the Soviet period and was restored by Vladimir Putin in 2000.

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"Flying tank" demonstrations have become a popular feature of Russian presentations at international exhibitions, such as this example during its international debut at the IDEX-97 show in Abu Dhabi in February 1997.

THE CHECHEN WAR

The Russian defense ministry planned to choose between the T-80U and the T-90 sometime in 1994 but this selection was delayed due to the accelerating budget shortfalls. The Russian Ministry of Defense was under pressure from regional political leaders who were concerned that the rejection of their tank would lead to further lay-offs and economic hardship in either Nizhni-Tagil or Omsk, where the T-72/T-90 and T-80 were still in production. The 1994–95 war in Chechnya accelerated the decision. The T-80, especially the earlier models, had a very bad reputation for high fuel consumption and low engine life. These problems were exacerbated by the improvised nature of the Chechnya deployments. When finally committed to combat in Grozniy, tank regiments with the T-80BV suffered appalling losses. These losses were mainly due to poor Russian tactics and poor crew training, not technical shortcomings of the vehicles. However, the loss of so many of Russia's best tanks to a modestly equipped foe perplexed and angered senior Russian military leaders including Minister of Defense Pavel Grachev.

The T-90 benefited from the Chechen war for several reasons. Its use of a more economical diesel engine gave it an advantage over the T-80U with its expensive turbine engine. It was not smeared in the press for poor performance in Chechnya since it was not deployed there. Its new marketing name distanced it from the T-72s which were also lost in significant numbers in Chechnya. In January 1996, Colonel General Aleksandr Galkin, chief of Main Armor Directorate of the Russian Ministry of Defense (GBTU), confirmed that a decision was made to gradually move to the T-90 as the single production tank of the Russian Armed Forces. The key expression in this decision was the phrase "gradually move." In other words, T-80U

production at Omsk would continue at a low rate in spite of the T-90 selection to prevent undue economic hardship in Omsk, with the T-80U production intended primarily for export. In the event, T-80U production did not end until 2001.

Later in September 1996, Gen Galkin labeled the T-90 decision "a mistake" and he acknowledged that he still considered the T-80U to be a superior tank. He considered the T-90 overweight and underpowered when compared to the very nimble T-80U. Regardless of the decision to standardize the T-90, there was very little funding for the purchase of new tanks in the second half of the 1990s. There are no official figures for T-90 production during this decade, but published figures estimate 120 tanks, mostly in the first half of the decade. Most T-90 production tanks were delivered to units in Siberia and Asia. About a hundred were deployed, starting in 1995 with the 21st Taganrog Motor Rifle Division near Omsk in the Siberian Military District and with the 5th Guards Tank Division near Kyakhta in Buryatiya in the Baikal Military District near the Mongolian border.

To add to the woes of the Russian tank industry, exports of new Russian tanks collapsed in the 1990s. Soviet tank exports in the 1980s had averaged about 975 annually. In the early 1990s, they fell to less than half this level, and between 1994 and 1999 they fell to only 125 annually, many of these second-hand tanks. New export orders for UVZ fell to starvation levels. The standard UVZ export tank at this point was the T-72S, the export version of the T-72B tank. The T-72S was demonstrated to China, India, and Syria in 1992 and 1993 without eliciting a significant export order. One of the few contracts keeping the production line running was an existing contract with Iran from November 13, 1991 for the purchase and assembly of 1,000 T-72S tanks and 500 BMP-2 infantry vehicles at a new vehicle plant set up with Russian assistance at Dorud in Lorestan province. The first 100 T-72S tanks were delivered by Russia in 1993, followed by 22 more between 1994 and 1996. The Dorud plant became operational in July 1997 and UVZ provided a further 300 knocked-down T-72S kits. However, the US government put diplomatic pressure on Russia to halt arms sales to Iran. Under a May 1995 protocol, the remainder of the 1991 tank contract was canceled, subtracting 578 export tanks from the UVZ order book during the lean years of the late 1990s.

Tank development work at UVZ was funded at a very modest pace during the mid-1990s, and the plant survived largely due to its civilian railroad production. A variety of new tank engine options for the T-90 were explored, including Chelyabinsk's 1,000hp V-92S diesel engine. One of the spin-offs from the aborted Obiekt 187 program was its welded turret design. A version suitable for the T-90 was developed in 1996, partly due to ballistic improvements but also due to production issues at the casting plants. The welded turret also offered greater internal volume. An important factor forcing changes in the T-90 design was the economic collapse of many of the sub-contractors providing parts to Nizhni-Tagil. The supply of the existing track design ended in 1996, and there was concern that both plants manufacturing tank gun barrels would go out of business due to a lack of state orders. This led to the substitution of new subcomponents in some cases. For example, in the case of tracks, UVZ examined several new track options for the T-72 and T-90 and production was subsequently started at the Titran plant in Tikhvin.

REDEMPTION: THE INDIAN BHISHMA ORDER

Due to the decline in Russian army orders for the T-90, UVZ finally received government approval to sell the T-90S overseas. Its international debut was in February 1997 at the IDEX exhibition in Abu Dhabi. The IDEX exhibition caught the attention of a visiting Indian delegation.

India had already purchased the T-72 and was manufacturing it under license as the T-72 Ajeya. India had conducted trials of the Omsk T-80U and Nizhni-Tagil T-72S in 1993, but had decided that neither was a sufficient advance over their T-72 Ajeya. The Indian Army was becoming increasingly concerned about the tank balance with Pakistan after a July 1996 announcement that Ukraine had agreed to sell it 320 improved T-80UD tanks including guided projectiles. India had held meetings with Ukraine in the past and was fully familiar with the advantages of the T-80UD. Following the T-90S debut at IDEX, India approached Russian officials about a potential purchase. However, India had a set of conditions linked to the T-80UD's features, including a demand that any new tank would have to have an engine of at least 1,000hp, a thermal imaging sight, and a guided projectile.

In May 1998, the Indian government signed a preliminary understanding over the purchase of 310 T-90S tanks on the condition that they were successfully demonstrated at Indian trials. UVZ prepared three demonstration tanks. To meet the Indian engine requirement, they were fitted with the Chelyabinsk V-92S2 1,000hp diesel engine. One of the three tanks was also fitted with the new welded turret. Three different sights were fitted to the different tanks. The Russian Zenit plant in Krasnogorsk offered the Buran-PA image intensification sight and the Noktyurn thermal imaging sight. The Belorussian firm Peleng offered their ESSA thermal imaging sight, which was based around the French Thales Catherine-FC focal plane array. The three tanks were airlifted to India in May 1999 for extensive trials.

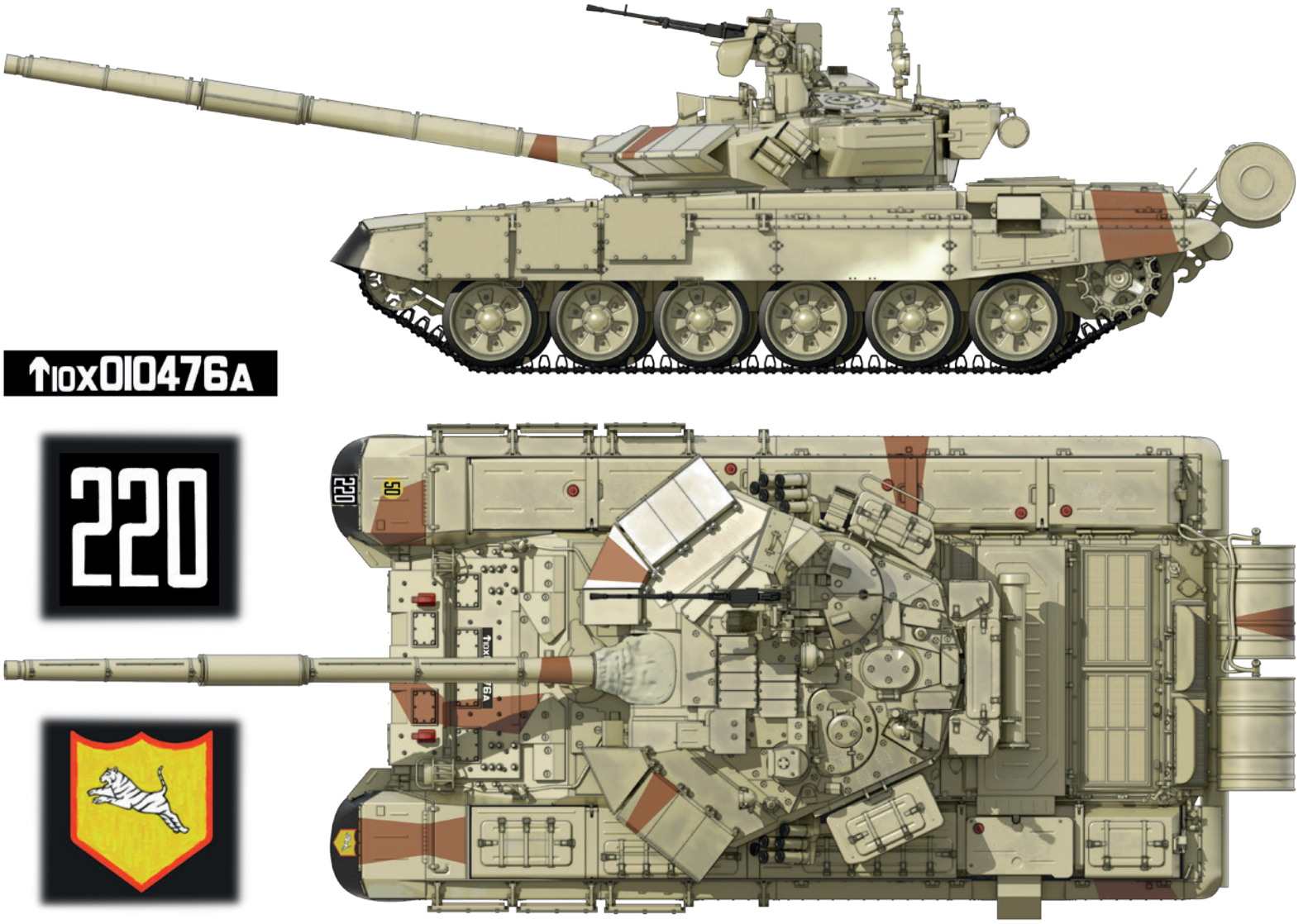
Due to the Pakistani acquisition of Ukrainian guided projectiles for their T-80UD tanks, India insisted on a similar capability for their T-90S tanks. This led to the development of an improved version of the Refleks guided projectile, the Invar. The Invar family includes two projectile types, the 9M119F with a thermobaric blast warhead and the antiarmor 9M119M Invar with a HEAT warhead.

C

T-90S BHISHMA, INDIAN 31ST ARMOURED DIVISION, REPUBLIC DAY PARADE, NEW DELHI, JANUARY 2015

The standard delivery scheme for the T-90S Bhishma delivered from the Avadi HVF is an overall sand color. This scheme is adapted to local circumstances, with some units opting for a desert-oriented pattern while other units add colors more suitable for tropical climes. In the case of the 31st Armoured Division based in Jhansi with the Southern Command, the scheme often leans to the desert patterns, as seen here, with small disruptive bands of brown on the sides.

Indian Army tactical markings remain heavily influenced by British World War II practices. On the left front mudguard is the divisional insignia, a white Bengal Tiger on a yellow shield. On the right mudguard is the regimental arm-of-service sign distinguishing the division's five regiments (83rd, 12th, 13th, 15th, and 19th Armoured Regiments) numbered 220 to 224. Behind the arm-of-service insignia is a bridging circle, a black 50 in a yellow circle. The tank registration number is painted on an elongated black rectangle. The first symbol is the upward pointing "Broad Arrow," retained by the Indian Army to identify military vehicles. The small set of two numbers following this represent the year the vehicle was procured, in this case fiscal year 2010, followed by a base letter, the tank registration number, and a letter suffix.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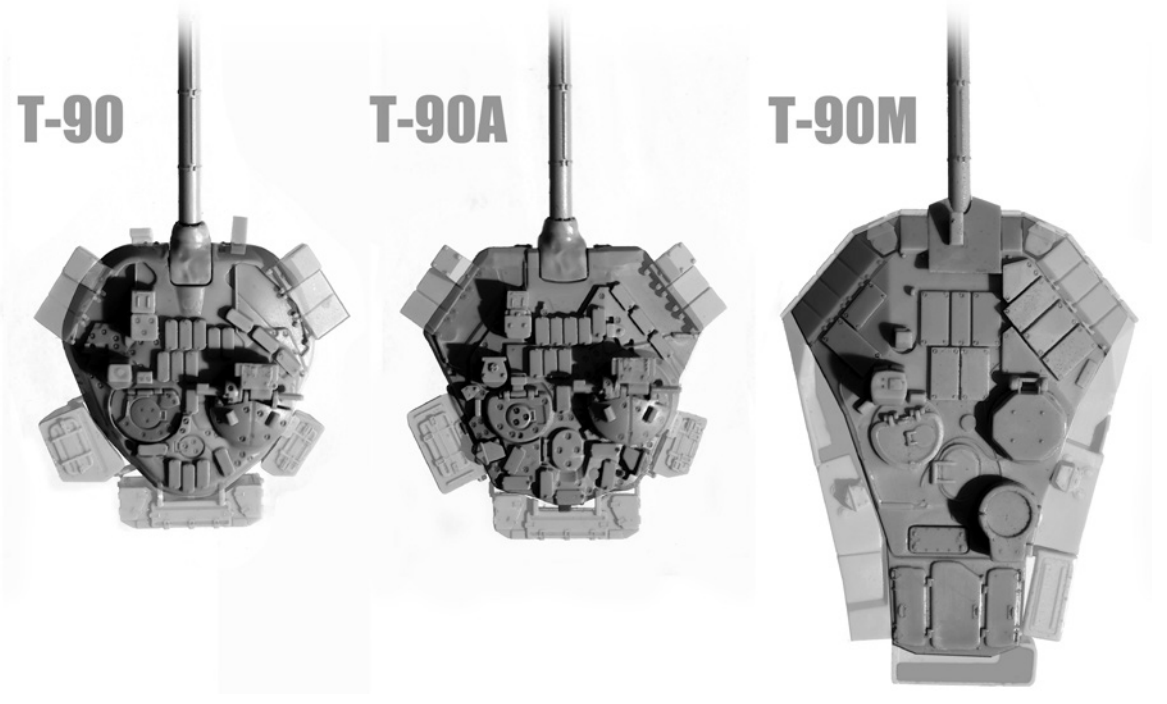

The dramatic changes in shape of the T-90 turret are hidden by the layers of reactive armor and stowage bins. This computer illustration strips away many of the sub-assemblies to better reveal the changing shape of the T-90 turret, from the cast turret of the T-90, the welded turret of the T-90A to the enlarged turret with bustle of the T-90AM.

The trials uncovered some issues with engine overheating during intensive desert trials, but technical remedies were offered. The Peleng ESSA sight was the preferred option for the night-fighting requirement. In the spring of 2000, the Indian Ministry of Defence approved the purchase of 310 T-90S tanks. The price-tag on this program was pegged at around $700 million, but the Indian parliament at first balked at the deal due to concerns that Russia had increased the price-tag from $2.1 million to $2.8 million per tank, partly due to the cost of the French sight. The sale was important enough that president Boris Yeltsin personally intervened in the negotiations, visiting India from October 2 to October 5, 2000. The contract was signed on January 15, 2001.

Under the program, India received 124 finished tanks from Russia while 186 would be assembled from knocked-down kits at the Avadi Heavy Vehicle Factory (HVF) that was already manufacturing the T-72 Ajeya. The Indian Army named the T-90S as Bhishma[3] after the legendary warrior of the *Mahabharata* epic. Russia delivered the first batch of 40 T-90S tanks to India in 2001, fitted with the original cast turret. Aside from the first 42 tanks, all subsequent T-90S deliveries had the welded turret. The first 84 T-90S with welded turrets were delivered in 2002, followed by the final batch in 2003. The knocked-down kits for Indian assembly quickly followed, with 40 delivered in 2002, 126 in 2003 and 20 in 2004. The first Indian-assembled tank was completed on January 7, 2004. The initial T-90S tanks were deployed in tank regiments of the XXI (Bhopal) and II (Ambala) Strike Corps.

The Indian government subsequently announced plans to manufacture an additional 1,000 T-90S Bhishma tanks at the Avadi HVF. This process was delayed due to disagreements between both sides over technology transfer,

3 Also spelled as Bishma and Beeshma.

especially concerning the manufacture of the gun and the armor package. There were also problems with the Invar guided 125mm projectile, with the Indian press reporting that a batch of missiles obtained prior to local manufacture had to be returned. Further complicating the program was a problem integrating the Indian-manufactured 125mm ammunition with the fire-control system due to small performance differences with Russian-manufactured ammunition.

One of the first public displays of the new T-90A occurred at the Omsk VTTV exhibition in Siberia in June 1999. It is difficult to distinguish the welded turret on the T-90A from the cast turret on the earlier T-90 due to the profusion of appliqué armor panels and other subcomponents attached to the turret shell.

The delay in starting the local manufacture led to considerable consternation in the Indian Army, and the government finally agreed to purchase another batch of 347 T-90S tanks directly from Russia. This consisted of 127 complete tanks and 223 knocked-down kits. An initial batch of 19 T-90S and 5 T-90SK command tanks from this contract arrived in 2008.

In July 2006, the Ordnance Factories Board announced that the government had authorized the manufacture of 1,000 T-90S Bhishma tanks from its network of plants, starting with an initial contract for 300. The first tank was delivered in August 2009 as part of the batch of 24 tanks under the 2009–10 budget, with 51 more in 2010–11, 50 in 2011–12 and the remainder in 2012–13. With these complete, on September 13, 2013 the Defense Acquisition Council authorized a second contract for 236 more T-90S tanks from the Avadi plant, bringing the total to 536 locally-manufactured tanks. The Indian Bhishma tank manufacturing program involved a wide range of factories that were part of the government-managed Ordnance Factory Board. The gun was manufactured at OFB Kanpur factories, the night sight at OFB's Opto-Electronics Factory in Dehradun, and the engine at the Avadi Engine Factory. The Invar 125mm guided projectile was manufactured by Bharat Dynamics, India's main missile manufacturer. The Indian requirement was for 25,000 guided projectiles, with 10,000 acquired from Russia and the remaining 15,000 to be manufactured in India.

Initial T-90A Production

		2001	2002	2003	2004	2005	2006	2007	2008
T-90A	Russia	–	–	–	14	17	31	25	62
T-90S	India	40	84	–	–	–	–	–	60
T-90S	India kits	–	40	126	20	–	–	–	–
T-90SA	Algeria	–	–	–	–	–	58	74	53

THE OBIEKT 188A: T-90A VLADIMIR

Russian state orders for the T-90 tank largely collapsed by the end of the 1990s due to a lack of defense funding; only one tank was funded in the 1999 budget. The Indian Bhishma contract helped keep development work alive at UVZ, and the various improvements were packaged together for

Distinguishing the T-90 cast from the T-90A welded turret is only obvious from the side. The distinctive flat plate of the T-90A welded turret is evident between the Kontakt-5 reactive armor towards the front and the Tucha smoke grenade launchers further towards the rear.

Russian Army use as the Obiekt 188A, or T-90A. The chief designer at UVZ, Vladimir Potkin, died in 1999 and as a result the T-90A tank was unofficially named in his honor as the "Vladimir."

Three different configurations were offered to the Russian Army, the Obiekt 188BA with the domestic Zenit Buran-M thermal imaging sight, the Obiekt 188B1A with the Agava sight or the Obiekt 188B2 with the imported Peleng ESSA thermal imaging sight. Another improvement developed for the Russian tanks was the new 2A46M-5 version of the 125mm gun, which reduced dispersion while firing on the move. When Russian state orders finally resumed in 2004, the first Russian T-90A batch (Obiekt 188BA) was ordered with the Buran-M sight. The T-90A was officially accepted for Russian army service on April 15, 2005. Government funding improved in the second half of the decade, with enough funding in 2006 to permit acquisition of T-90A tanks with the ESSA thermal imaging sight. The core of the ESSA sight is a Thales Catherine-FC focal plane array, which was a second-generation device offering better resolution than its indigenous Buran-M competitor. However, it added significant cost to this version. After importing the Catherine-FC modules for both domestic and export tanks, license production began at VOMZ (Vologodskiy optiko-mekhanicheskiy zavod) in Vologda in 2012.

The T-90A was the first Russian tank adapted to network-centric warfare and was called the YeSU-TZ. This system allows the digital transfer of data

D

1: T-90S BHISHMA, 31ST ARMOURED DIVISION, BABINA MILITARY STATION, OCTOBER 2010

This is another example of a T-90S of the 31st Armoured Division during a ceremony at Babina Station. The base color is the usual sand, but with bands of dark green and medium brown in a disruptive pattern.

2: T-90S BHISHMA, MAHARASHTRA AREA, SOUTHERN COMMAND, INDIAN ARMY, 2013

Some Indian Army T-90Ss have been finished in very vivid color patterns intended for use in tropical regions. In this case, the T-90S is finished in a disruptive pattern of dark green and chrome yellow.

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A T-90A at the Alabino proving ground, part of the Russian Army's Kubinka tank testing facility outside of Moscow. The Russian Army moved away from multicolor camouflage due to a directive by defense minister Sergey Shoigu in April 2013 to a plain overall green finish, evident here.

and imagery to and from individual tanks as well as supporting units. The concept was explored under the Sozvezdie-M2 research program as part of a broader effort to digitize Russian army command and control. The new system led to the adoption of the R-168 family of digital radios. The system is software driven and serves as the digital interface between the tank's PTK digital computer, AVSKU communications system, and the 14Ts821 Grot-V GLONASS/GPS satellite navigation system. The system was first deployed in 2010 in two variants, the PTK-T-2 for line tanks and the PTK-T-1 with T-90AK command tanks.

The T-90A also used the Chelyabinsk V-92S2 1,000hp diesel engine and a number of other automotive improvements.

At the beginning of 2012, Russia had about 490 T-90 tanks, including about 120 T-90, 25 T-90A (Obiekt 188A-1 Buran-M), 7 T-90AK (Buran-M), 287 T-90A (Obiekt 188A-2 ESSA) and 50 T-90AK (ESSA). There were plans to halt T-90 acquisition for the Russian Army in 2012. This was due to the advent of a follow-on tank, the T-14 Armata, as well as plans to modernize existing T-72B tanks into the T-72B3 configuration, which offered similar capabilities to the T-90 at lower cost.

A T-90A on display at Patriot Park in Kubinka outside Moscow in September 2016 at the Army-2016 exhibition.

FURTHER T-90 EXPORTS

The T-90A also appeared in an export variant, the T-90SA, developed primarily for a March 2006 Algerian export contract. This consisted of 185 T-90SA and T-90SKA command tanks delivered between 2006 and 2009 as part of a package that included modernization of 250 older T-72 tanks. Algeria was negotiating for the purchase of a further 120 T-90S tanks in 2011, and signed a contract in February 2015 for local assembly of 200 T-90S tanks using knocked-down kits.

There were several other T-90 exports. Turkmenistan ordered 10 T-90S in 2009. Uganda received 44 T-90S tanks in 2011. Azerbaijan ordered some T-90S tanks in 2014, reported as 98–100 tanks. Syria began receiving T-90 tanks in 2015. Most of the initial Syrian tanks were older Russian Army T-90 with the original cast turret, but subsequently, the improved T-90A became the predominant type. They were deployed during the civil war, serving with elements of the Syrian 4th Mechanized Division as well as several other militias and factions. In 2017, Iraq ordered 73 T-90S, Vietnam 64 T-90S/SK, and an order was expected for 146 T-90MS for Kuwait.

THE OBIEKT 188M: T-90AM TAGIL

As the two remaining Russian tank plants, rivalry developed between UVZ in Nizhni-Tagil and Transmash in Omsk. The Omsk plant was trying to win export orders for its T-80U tank at the same time that Nizhni-Tagil was trying to export the T-90. Omsk expanded its design bureau in the 1990s in the hopes of becoming a more serious rival. This included the development of a radically improved version of the T-80U, the Obiekt 640 Black Eagle. The Russian Ministry of Defense was impressed enough with Omsk's concepts that it funded the OKR Burlak research program, an effort to develop a "universal" turret that could be used to upgrade existing tanks including the T-64, T-72, and T-80. In the face of this challenge, UVZ undertook its own turret upgrade effort under the OKR Proryv-2 (Breakthrough) research program. The first demonstration of the Proryv turret was made at Nizhni-Tagil on December 8, 2009 during a visit by President Vladimir Putin. With Russian Ministry of Defense support, the new turret was incorporated into the T-90 as Obiekt 188M, later designated as T-90M or T-90AM. The main focus of the program at this stage was the export market, since by this time the Russian government was supporting the development of an entirely new tank at UVZ, the T-14 Armata. The export version of the T-90AM was first described as "T-90S Modernized" when publicly unveiled in 2011, but in recent years it has been more formally named as T-90MS.

The international debut for the T-90MS Tagil was at the Eurosatory-12 exhibition outside Paris in June 2012. UVZ developed a special export scheme for tanks aimed at the international market.

The T-90MS again appeared at the IDEX-13 exhibition in February 2013 in Abu Dhabi, seen here during the mobility display. The vehicles that appeared at the international exhibitions have differed in small details from one another, a hint that development of the design was still ongoing.

The T-90MS represented a deep modernization of the T-90. The welded turret has a core very similar in shape to the welded turret of the T-90A, but with a protected bustle added in the rear, containing ammunition. Russian studies of combat experiences concluded that a major source of catastrophic ammunition fires in the T-72 tank was the ammunition scattered around the fighting compartment, not necessarily the ammunition in the autoloader cassette in the hull floor. By shifting ten rounds of this ammunition into the new protected bustle, the threat of ammunition fires was reduced while at the same time freeing up space for a much more extensive array of sensors and electronics. This bustle has blast doors to separate it from the fighting compartment in the event of an ammunition fire. Of the remaining ammunition, 22 rounds are in the improved AZ-185M2 autoloader cassette and 8 on the engine compartment bulkhead. The AZ-185M2 autoloader is a new design that permits the use of longer APFSDS 740mm long-rod penetrators. This is a very important feature since the earlier versions of the AZ-185 had limited the maximum length of 125mm APFSDS penetrators, restricting the penetration performance of the 125mm gun.

The external appearance of the T-90MS turret differs significantly from the T-90A due to the use of a new generation of reactive armor codenamed Relikt. This was developed by NII Stali and incorporates the new 4S23 explosive modules.

E

1: T-90S, TURKMENISTAN ARMORED BRIGAGE, ASHGABAT, TURKMENISTAN, OCTOBER 2014

The Turkmenistan T-90S tanks were first revealed in a parade in 2014 celebrating the 25th anniversary of independence from the former Soviet Union. The color scheme is a variation of the former Soviet three-color scheme but in desert colors consisting of a base sand color, bands of medium brown and a very dark brown disruptive pattern. For the parade, the tanks were painted with the army flag, which consists of the national flag with the army cocarde imposed to the left.

2: T-90SA, AZERBAIJAN ARMY, BAKU, JUNE 2013

This is the color scheme painted on the T-90 tanks participating in the June 26, 2013 military parade in Baku marking the 95th anniversary of the Azerbaijani Armed Forces. The scheme consists of three principal colors of sand, dark green, and medium brown with a black disruptive pattern. No tactical markings were evident.

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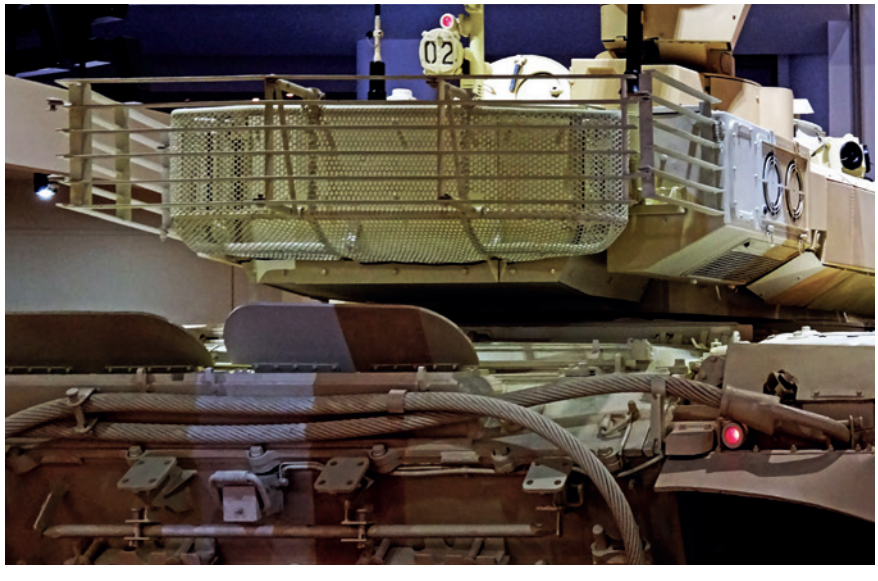
One of the options with the T-90MS is the Nakidka camouflage cover, developed by NII Stali in Moscow. This reduces the thermal image of the tank by a factor of two to three times. This is an important feature, considering that thermal imaging devices have become essential to modern tank and missile fire-control systems.

The turret sensor array is substantially different from previous T-90 variants due to the adoption of the integrated Kalina SUO (fire-control system). The Kalina offers the gunner and commander an automatic target tracking capability as well as digital processing to enhance the image. The Kalina system is most evident from the reorganization of the tank commander's station. Instead of the commander's sight and antiaircraft machine gun being mounted at the front of the commander's cupola, a new module has been added behind the commander's hatch. This consists of the Hawk Eye (*Sokoliniy glaz*) stabilized panoramic commander's sight with both daylight TV and thermal imaging channels and an integral laser rangefinder. This offers the commander a more complete sight picture than previous configurations due to its higher location and wider field of view. Behind this is the T05BV-1 remotely-operated overhead weapons station (OWS) with a 7.62mm 6P7K machine gun. The T05BV overhead weapon station is a modular design and can be fitted with alternative weapons including the 12.7mm 6P50 Kord heavy machine gun.

The commander and gunner are provided with digital imagery around the turret from four small digital cameras mounted around the turret exterior, plus additional small cameras on the wind sensor stalk. The commander's hatch itself is a significant change from previous Soviet/Russian designs, which usually opened vertically towards the front, preventing the commander from keeping his head out of the hatch in the combat environment. The new hatch is similar to those used on American and German tanks, which pop upward, allowing the commander to peer over the edge while still having overhead cover.



The Indian Army had complained about the degradation in performance of onboard electronics when the T-90S operated under extreme desert heat. As a result, UVZ developed an air-conditioner option for the T-90MS, seen here on the right side of the turret of the tank displayed in February 2015 at the IDEX-15 exhibition in Abu Dhabi.

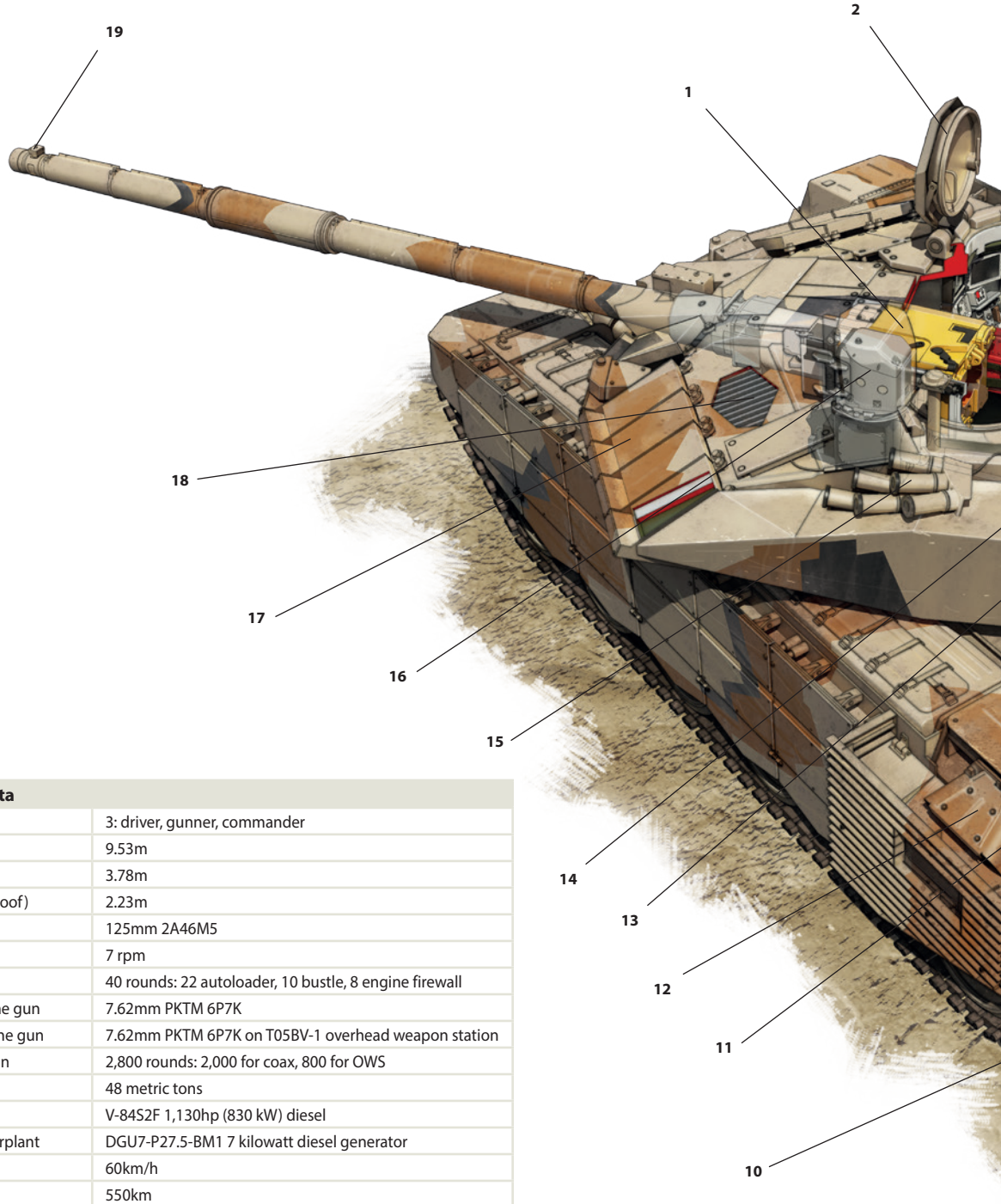
The T-90MS introduced several new features to the design, including this improved commander's cupola, which has a hatch that can be raised overhead to permit the commander to view outside the tank while remaining protected from overhead airbursts and sniper fire. Behind the hatch is the panoramic day-night sight and new remote weapon station with 7.62mm machine gun.

The gunner has the usual pair of sights. There is a Peleng Sosna-U panoramic sight with thermal imaging immediately in front of the gunner's hatch, and the 1G46M primary fire-control sight immediately in front of this. The main difference with the new fire-control system is that the gunner is provided with a unified sight picture through a single panel display.

The T-90MS is fitted with the 2A46M-5 125mm gun, first accepted for service in 2005 and the standard type on all T-90 versions subsequently manufactured. The Proryv-2 research project was accompanied by the development of a new family of 125mm projectiles including two APFSDS projectiles with 740mm long-rod penetrators. These are the 3BVM22 round with 3BM59 Svinets-1 projectile with depleted uranium penetrator and the 3BVM23 round with 3BM60 Svinets-2 projectile with tungsten carbide penetrator. Both use the improved 4Zh96 Ozon-T propellant casing. The T-90MS can also fire the remotely detonated Aynet projectiles that were introduced on the T-90 in the 1990s. The early Aynet system did not offer the level of accuracy expected due to shortcomings of the laser rangefinder, but the Kalina fire-control system largely remedied the problem and doubled the system effectiveness.

The heavier weight of the T-90MS led to the introduction of the V-92S2F engine, which boosted the power from 1,000 to 1,130hp.

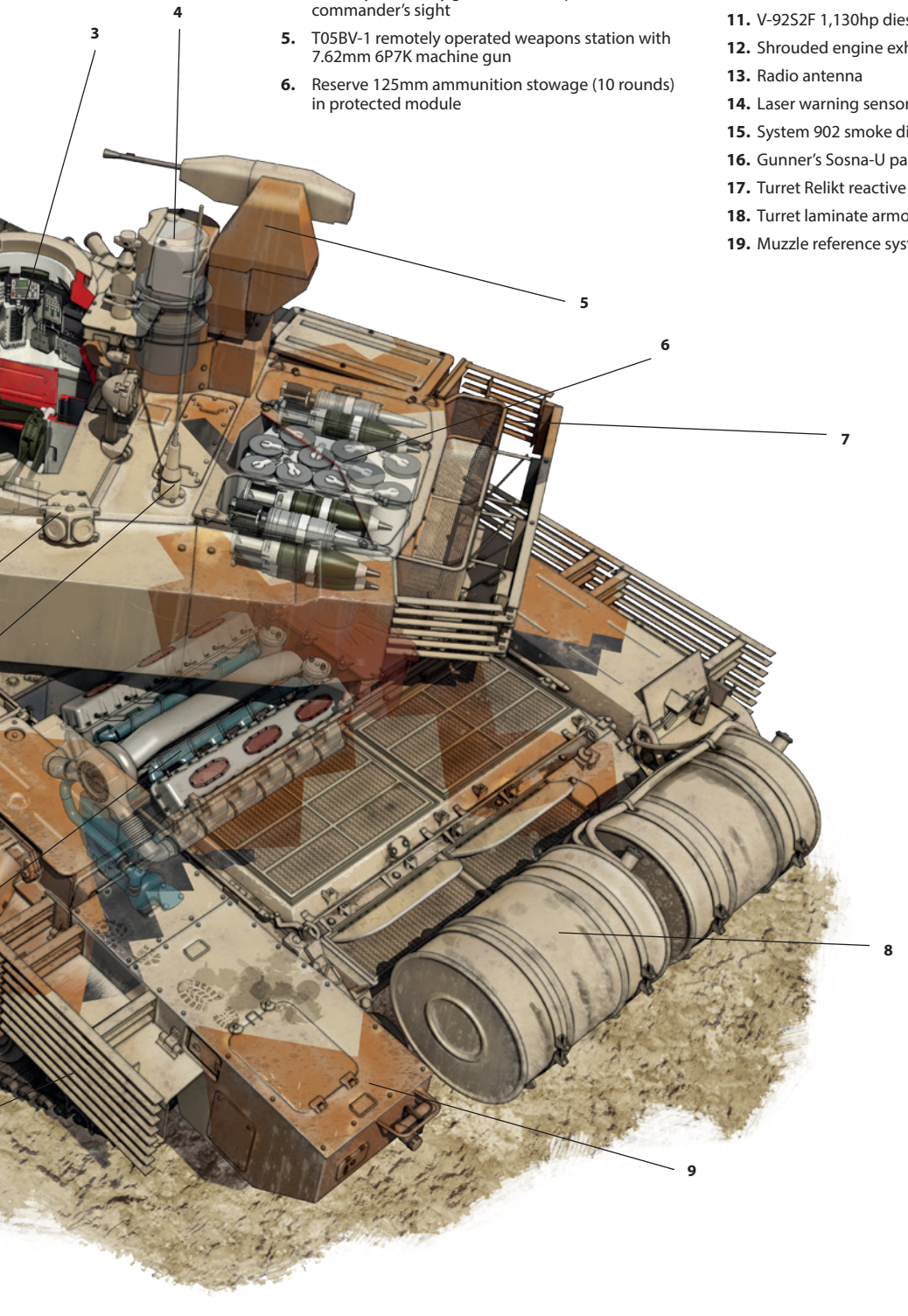
The first client for the T-90MS was India, which announced in November 2016 a plan to acquire 464 T-90MS tanks. This actually was a reorientation of the existing contract with the Avadi HVF contract, which had called for the local manufacture of 1,000 T-90S Bhishma tanks. Prior to 2016, there had been two production contracts to Avadi in 2006 and 2012 for a total of 536 tanks, and the construction of 464 T-90MS will round this out to 1,000. At the time of writing, the Indian press was reporting that the Indian Army



Technical Data	
Crew	3: driver, gunner, commander
Length	9.53m
Width	3.78m
Height (turret roof)	2.23m
Gun	125mm 2A46M5
Rate of fire	7 rpm
Ammunition	40 rounds: 22 autoloader, 10 bustle, 8 engine firewall
Coaxial machine gun	7.62mm PKTM 6P7K
Exterior machine gun	7.62mm PKTM 6P7K on T05BV-1 overhead weapon station
MG ammunition	2,800 rounds: 2,000 for coax, 800 for OWS
Weight	48 metric tons
Powerplant	V-84S2F 1,130hp (830 kW) diesel
Auxiliary powerplant	DGU7-P27.5-BM1 7 kilowatt diesel generator
Road speed	60km/h
Range	550km

KEY

1. Breech of 125mm 2A46M-5 gun
2. Commander's multi-position hatch
3. Commander's station
4. Hawk Eye (*Sokolniy glaz*) stabilized panoramic commander's sight
5. T05BV-1 remotely operated weapons station with 7.62mm 6P7K machine gun
6. Reserve 125mm ammunition stowage (10 rounds) in protected module
7. Rear turret slat armor
8. Reserve fuel tanks
9. Auxiliary power unit
10. Rear side slat armor
11. V-92S2F 1,130hp diesel engine
12. Shrouded engine exhaust
13. Radio antenna
14. Laser warning sensor
15. System 902 smoke dischargers
16. Gunner's Sosna-U panoramic sight
17. Turret Relikt reactive armor
18. Turret laminate armor
19. Muzzle reference system



would like to acquire some number of T-90MS as soon as possible, directly from Russia, to be followed by local production. In early 2017, there were reports that a second order for the T-90MS had been secured from Kuwait.

In 2016, the Russian press reported that the army was considering procurement of the T-90AM Proryv-3 as a less expensive alternative to the T-14 Armata. The T-90AM Proryv-3 is essentially similar to the export T-90MS, but incorporates features such as the YeSU-TZ network-centric suite specific to the Russian army.

T-90 Tank Designations

Russian Army	Development designation	Export variant	Development designation
T-90	Ob. 188B	T-90S	Ob. 188S
T-90K	Ob. 188BK	T-90SK	Ob. 188SK
T-90A	Ob. 188B	T-90SA*	Ob. 188S
T-90AK	Ob. 188B2K	T-90SKA	Ob. 188SAK
T-90AM	Ob. 188M	T-90MS	Ob. 188M

*"SA" indicates Algerian export version

THE T-90'S RUSSIAN RIVALS

The development of the T-90 tank took place within the tumultuous first decades of the new Russian Federation. The production program was threatened on many occasions by shortfalls in the Russian defense budget that led to drastically reduced orders for new tanks. Having survived its competition with the T-80U, the T-90 faced other rivals in the late 1990s. After being challenged by equivalent competitors, the T-90 was soon faced with next-generation tank designs. Omsk designed a deeply modernized version of the T-80 called the Black Eagle. This never received sufficient funding to emerge as a real rival, and eventually disappeared as the Transmash plant in Omsk slid into bankruptcy. Its real challenge came from another UVZ design, the Obiekt 195, also sometimes called the T-95.

There have been numerous upgrade packages for the T-72B that have competed with the T-90 in the export market. This "urban warfare" package was displayed at the RAE-13 show at Nizhni-Tagil in 2013. It includes a dozer blade and improved armor appliqués, including hemispheric protection against RPGs using "reshetka" grill armor and an armored antisniper pulpit for the commander. (Christopher Foss)

A debate has raged within the Russian Army for more than a decade about whether it is more prudent to buy new T-90 tanks or spend the same money to bring a larger number of T-72B tanks closer to the combat capabilities of T-90 through a modification program. In 2016, the Russian Army funded UVZ to upgrade a thousand T-72B to the new T-72B3 standards. This example of the T-72B3M with the new side reactive armor was shown at the Army-2017 show at Kubinka in August 2017.

Following the cancellation of the Obiekt 187 program, Nizhni-Tagil was assigned a follow-on next-generation tank program around 1988, variously called the Obiekt 195 and T-95. The design characteristics for a future tank were outlined by the study entitled Sovershenstvovanie-88 (Improvement-88) in 1988. The layout of the Obiekt 195 was unconventional, with a well-protected crew "cocoon" in the front of the tank consisting of the driver, commander, and gunner sitting side by side. The crew compartment was separated from the armament compartment by a blast wall to reduce the vulnerability of the crew in the event of an ammunition fire. The armament module was located in the center of the tank with an autoloader carousel below the externally mounted gun. The vehicle sensors and self-defense system were mounted on the turret. The armament for the Obiekt 195 was the 2A83 152mm gun developed by the Zavod No. 9 in Yekaterinberg. This included a new family of ammunition including the Grifel APFSDS projectiles. Several options were studied for vehicle propulsion including a Chelyabinsk A-85-3 1,500hp "X" configuration diesel, a Barnaul "X" configuration 1,650hp diesel, and a Klimov 1,500hp gas turbine. The chassis was derived from earlier work on the Obiekt 187, but lengthened with an additional road-wheel station for a total of 7 per side. NII Stali developed the armored package for the Obiekt 195, including a variant of the Relikt system for reactive armor. The protection level objective was 1,000mm versus APFSDS and 1,500mm against shaped-charge attack. Various forms of active defense systems were considered.

Progress on the Obiekt 195 was delayed by the lack of funding through most of the 1990s, and did not resume in earnest until 2000–2001. State testing was completed in 2006 with plans to start production in 2007, but this date continually slipped. The Obiekt 195 program was canceled in April 2010. Various explanations have emerged for its demise, including its excessive price tag, technical issues with the sensors, and other factors. The veil of secrecy around the program had not been lifted at the time of writing.

The cancelation of the Obiekt 195 program was soon followed by a new experimental design study at UVZ, OKR Armata (Armament). Besides developing the new Obiekt 148 main battle tank, the program also incorporated

The T-90's high-end rival in the early 2000s was the Obiekt 195. This was a much larger and heavier tank with an unmanned turret armed with the 2A83 152mm gun. It was canceled in 2010 before reaching series production.

a requirement to develop a universal chassis that could be used for other types of armored vehicles, including the Obiekt 149 heavy infantry fighting vehicle and Obiekt 152 armored recovery vehicle. The Obiekt 148 tank is an evolutionary development from the Obiekt 195 and also employs a crew cocoon in the front of the tank with a blast wall separating it from the external overhead gun system. This requires the use of a more elaborate sensor system for the crew than on previous Russian tank designs, including themal imaging systems for gunner and commander. A new gun was developed for the tank under the OKR Levsha study program, resulting in the 2A82-1M 125mm gun. This included a new family of ammunition including the Vakuum-1 APFSDS, Telnik overhead air-burst round, and 3UBK21 Sprinter guided projectile. Due to the use of a deeper autoloader, the Vakuum APFSDS round is based around a 1,000mm-long penetrator, compared to the 760mm penetrator used in the T-90AM. The Armata is powered by a Chelyabinsk 1,500hp A-85-3A diesel engine. The Armata is fitted with conventional armor plus an appliqué of Malakhit universal reactive armor. Its active defense system is codenamed Afghanit and uses a mm wave sensor to track incoming missiles, which are then attacked using special munitions launched from the turret. The T-14 Armata was first unveiled in 2015 and entered serial production in 2016. Russian press reports indicate a production requirement of about 2,300 Armata tanks through 2020.

With the arrival of the Armata family anticipated, Russian Army orders for the T-90A largely disappeared after 2012. There was some debate as to whether it was worthwhile to fund additional T-90A tanks with the new tank around the corner, or whether the money would be better spent to upgrade older T-72B tanks to a higher standard and closer in capability to the T-90A. In this fashion, the T-90A production program was squeezed both from the top by Armata and from below by the T-72B modernization program.

The Obiekt 195 program gave way to the Obiekt 148 Armata, another attempt to develop a tank with a heavily protected crew module in the hull front and an unmanned turret. The Obiekt 148 was accepted for service use as the T-14 tank and is seen here in August 2017 at the Army-2017 exhibition at Patriot Park in Kubinka.

The T-72B modernization program has been an ongoing process since the 1990s, not only directed at Russian Army requirements, but at the international export market. One of the study programs, OKR Rogatka, examined a deep modernization of the T-72B and this option was displayed in 2002 as the T-72B2. This does not appear to have

been accepted for Russian Army use, and a less extensive modernization package was developed as the T-72B3. This includes the use of the improved 2A46M-5 gun, an upgrade of the fire-control system with the Peleng Sosna-U, and incorporation of digital communications. This has a more modest price tag than Rogatka, pegged at 52 million roubles ($880,000) per tank, of which 30 million roubles covers the necessary capital overhaul and the rest covers the new sub-assemblies. About 600 T-72B tanks were upgraded to this standard through 2016. UVZ received a second contract in September 2016 to upgrade 1,000 T-72B tanks to this standard. A deeper modernization has also been proposed, the T-72B3M, which uses the V-92S2 1,000hp engine, but which raises the cost to 79 million roubles ($1.3 million) per tank.

T-90 VARIANTS

As has traditionally been the case, the production of the T-90 for the Russian Army led to the manufacture of specialized support vehicles. In many cases, these were new variants of versions originally developed for the T-72 tank family. The main distinction between the T-90 variants and the T-72 variants was the substitution of the more powerful V-92 diesel engine. What is sometimes confusing is that UVZ continued to manufacture T-72 variants for the foreign export market that were essentially similar to their T-90 counterparts.

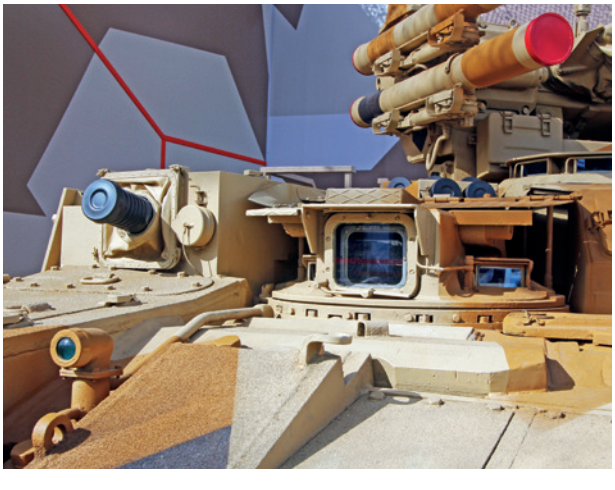
The BMPT Terminator Tank Support Combat Vehicle

One of the most radical versions of the T-72 and T-90 tank families is the BMPT, sometimes nicknamed the Terminator after the popular movie character. This is a new category of armored combat vehicle intended to provide direct fire support for main battle tanks. It first began in the early 1980s to deal with the threat posed by the large number of NATO antitank missile launchers. The idea emerged of accompanying the tanks with a BMPT tank combat support vehicle that would have more extensive observation devices as well as weapons

The original version of the BMPT debuted at the Uralekspoarms (Urals Arms Expo) at the Staratel artillery proving ground near Ekaterinburg in 2000. The early version was armed with a single 30mm cannon.

The BMPT Terminator was subsequently redesigned by adding a second .30mm autocannon and a more elaborate configuration of missile launchers. This is the example displayed in June 2012 at the Eurosatory exhibition in its UVZ export camouflage.

The BMPT has 30mm AG-17 automatic grenade launchers on the front corners of the hull, operated by the dismount team. The plastic cover over the grenade launcher is evident to the left in this close-up view.



better suited for the suppression of NATO antitank defenses.

The BMPT concept was first studied by the GSKB-2 design bureau at the Chelyabinsk Tractor Plant under V. L. Vershinskiy. While the Chelyabinsk plant studied the vehicle requirements, design bureaus of the missile industry studied a variety of armament options under a research program codenamed Suppression (NIR Podavlenie). Some of this work was a spin-off from earlier design efforts on the armament of the new BMP-3 infantry fighting vehicle. At least three configurations were built on modified T-72 chassis. Obiekt 781 had a pair of 2A42 30mm guns on an elevated weapons station, plus an Ataka ATGM to provide heavier firepower against armored vehicles. The Obiekt 781.sb-2 used a modified T-72 hull with a small turret fitted with a new 120mm gun. Obiekt 782 used a small turret similar to that fitted to the BMP-3 with a 2A70 100mm smooth-bore gun/missile launcher and coaxial 2A42 30mm autocannon. The use of a smaller turret freed up space inside the hull to permit a small dismount squad to be carried. These test vehicles used a 7-man crew of whom five could dismount. While under armor, four of the crew operated small sponson-mounted AG-17 30mm grenade launchers fitted at four stations around the hull. The prototypes were completed in 1989 and sent to the Chebarkul training division for trials. The final plans from the Frame research project (OKR Ramka) were to build a design on the new Obiekt 187 chassis under development at UVZ at the time. The program petered out with the end of the Cold War due to lack of funding and the closing of the Chelyabinsk design bureau.

The BMPT concept was resurrected in late 1998 by Gen S. A. Mayev, the head of Russia's main armored vehicle directorate, the GBTU. This was prompted by experiences in Chechnya. Tanks were not especially effective in urban areas. A particular problem was snipers armed with RPG-7 rocket grenades firing from the upper stories of apartment buildings. Tanks could not elevate their main gun sufficiently to engage such targets. Tank commanders attempting to use the externally-mounted 12.7mm machine guns were very vulnerable to automatic rifle fire. Aside from the lack of suitable weapons, tank crews were essentially blind in an urban environment since their vision devices did not offer a broad

enough field of view. Urban combat required view in all directions while the existing tank sights were oriented to frontal coverage. A resurrected BMPT program was attractive since the armament options were much better suited to urban combat. The 30mm cannon could be elevated to near vertical elevations, and the assortment of grenade launchers and other weapons offered better options for combat with hostile infantry. The idea of carrying a dismount squad was also attractive, if only to provide additional sets of eyes to observe the terrain and detect threats from all directions.

The new program began in 1998 and was given the codename of Frame-2 (OKR Ramka-2). The design effort was headed by V. B. Domnin, who took over the UVZ design bureau after Potkin's death. UVZ examined at least two configurations, one a simple conversion of existing T-72 tanks with 2A42 30mm autocannon mounted on either side of the turret with the 125mm gun removed, and the other the new Obiekt 199 design featuring a new fighting compartment that included a remotely-operated weapons station and sufficient internal volume for a small dismount squad. The design repeated some of the solutions that had been studied by Chelyabinsk BMPT, including the extensive use of 30mm grenade launchers for the dismount squad. The BMPT debuted at the 2nd Urals Arms Expo July 11–15, 2000 at the Staratel artillery proving ground in the Sverdlovsk region outside Ekaterinburg.

The new fighting compartment design added two additional crew stations to either side of the driver. The new turret had two crew stations for the gunner and commander. The vehicle was armed with a variety of weapons. The crew in the two hull stations operated a 30mm AG-17 grenade launcher, mounted in an armor box on the fenders at both front corners of the vehicle. The turret armament was centered around a 2A42 30mm autocannon on an overhead weapon station with a coaxial 30mm AG-17 grenade launcher. There was also a quad 9M133 Kornet missile launcher on the left side of the weapon station. The Kornet is an antitank missile, but with an optional thermobaric high-explosive warhead. The Kornet was chosen for its versatility, since it can be used either to defend against tanks or used in its high-explosive form to attack bunkers, buildings, or other targets common in urban warfare. This was a lesson from both the Afghanistan and Chechen wars, where it was found that normal ATGMs, while precise, lacked the high-explosive destructiveness desired when attacking troops in bunkers, caves, or other shelters. There was also a remote control 7.62mm PKT machine gun fitted over the right-side turret cupola. The accent on the weapons was to provide fire support against ATGM teams, or in an urban environment. The 30mm grenade launchers are indicative of this, with the weapons being able to engage multiple targets simultaneously. The 30mm autocannon was selected due

Since the BMPT Terminator was designed with urban combat in mind, it has hemispheric protection including an array of NII Stali "reshetka" grill armor on the rear.

The BMPT project spawned a new derivative in 2016, the BMPT-72 Terminator-2. This version is intended to be a low-cost option, with the combat module mounted in an existing T-72 or T-90 hull without the need for extensive reconstruction of the hull. It lacks the dismount team found in the original Terminator. This example was displayed at Kubinka at the Army-2016 exhibition.

to its high rate of destructive fire and its ability to penetrate any lightly armored target. More importantly, the elevated weapon station enabled it to engage targets at very high elevations, such as snipers in the upper stories of buildings.

All four weapons operators were provided with day/night sights. The grenadiers in front of the hull were provided with the standard day/night commander's periscope with a low light level image intensification periscope. The two crewmen in the turret were both provided with an independent day/night sight including a thermal imager and a laser rangefinder. As in Russian main battle tank designs, either crewman can operate the weapons, but it is usual practice for the commander to acquire the targets with his sight and hand them off to the gunner.

Armored protection on the BMPT was somewhat better than on contemporary Russian main battle tanks. The armor package is essentially similar to that on the T-90 tank, with Kontakt-5 reactive armor over the glacis plate and turret front. Protection of the rear was superior to that on the main battle tanks, as these areas are protected by NII Stali grill armor. This armor is designed to defeat RPG-7s and similar threats. A panel of this armor was fitted on both rear corners, and there were additional panels covering the rear of the superstructure and the hull rear. The vehicle is also provided with laser warning receivers. There are three LWR on the turret, each covering a 120-degree swath. A total of 12 smoke grenade launchers were fitted on the turret.

There was evidently some criticism of the original BMPT armament package, as the turret was substantially redesigned in 2002. Instead of a single 30mm autocannon, the second turret design increased to two 2A42 guns.

In addition, the missile armament was changed, with the Kornet giving way to the larger Shturm-SM (AT-6 Spiral). The missile change was short-lived, and it was subsequently replaced with the improved 9M120-1 Ataka-T (AT-9 Spiral-2). Over time, other changes were gradually made to the design, including the substitution of Relikt ERA for the earlier Kontakt. The BMPT was nominally based on the T-72 chassis, but for all intents and purposes it is a T-90 variant and uses the usual V-92S2 engine.

The BM-1 launcher vehicle of the TOS-1 Buratino system on display in Omsk in 1999. This version was based on a T-72A chassis.

Two prototypes were handed over for state testing in June 2005, which concluded in May 2006. The state testing commission recommended formal acceptance and the Russian press indicated that the BMPT was officially accepted for Russian Army service in 2009. However, in 2010, the new commander of the Russian Ground Forces, Gen Aleksandr N. Postnikov, removed the service approval and deleted funding for the acquisition of the BMPT, stating that it did not respond to modern combat requirements. Although government officials indicated that a company of BMPT would be funded in 2010, in early 2010 officials indicated that BMPT production funding had been cut both for new construction vehicles and conversions from existing T-72.

In spite of its rejection by the Russian Army, the BPMT has remained a prominent fixture in Russian export exhibitions. In 2010, Kazakstan ordered 10 BMPT, with the first three delivered in 2011. The BMPT is informally dubbed the Terminator and this name has been used in marketing.

The lack of export orders for the BMPT led UVZ to develop a less expensive alternative, the BMPT-72 Terminator 2. Unlike the baseline BMPT, which required a new hull with side sponsons, the BMPT-72 was based on a standard tank hull, with the new turret module replacing the normal tank turret. The BMPT-72 was designed either to retrofit older T-72 tanks or configured on new constriction T-72 or T-90 hulls. Since the design lacks the side sponsons, the BMPT-72 does not have the extra grenadiers found in the baseline BMPT and has only a three-man crew.

A BM-1 launcher of the TOS-1 Buratino system moving forward at a base outside Omsk in 1999 to conduct a firepower demonstration. Eight of the thirty launch tubes are loaded with rockets and the front and rear protective covers are stowed on top of the launch box.

TOS-1 Artillery Rocket System

In the 1970s, the Soviet Army began to test a new type of high-explosive warhead, called thermobaric explosives or fuel-air explosives. In contrast to conventional explosives that use a chemical containing both the oxidant and volatile matter, the content of the thermobaric warhead is an inert metal powder than can only be detonated when it is dispersed into an airborne aerosol. At that point, a special detonator within the warhead triggers the explosion. These warheads are also called

A BM-1 Buratino launches a MO.1.01.04 thermobaric rocket during a demonstration outside Omsk in 1999. It takes about 8 seconds to ripple fire the whole salvo of 30 rockets.

enhanced blast warheads, since they create a larger explosion than a warhead of comparable weight using conventional explosives. One of the first uses for this novel warhead was undertaken under the Buratino (Pinocchio) project at the Transmash plant in Omsk. The Omsk design bureau was primarily responsible for the Obiekt 634B RSZO multiple-launch rocket system launcher while Splav, the main Soviet rocket artillery plant in Tula, developed the associated MO.1.01.04 thermobaric rockets. The Soviet Army classified thermobaric warheads as flamethrower devices and so the system was designated as the TOS-1 heavy flamethrower system.

The TOS-1 Buratino was based around the BM-1 (*Boyevaya mashina*: combat vehicle) using the chassis of the T-72A tank. Design of the BM-1 took place under A. A. Lyakov at Omsk from 1977 to 1982. A large launcher was fitted in place of the usual turret, with launch cells for 30 220mm rockets. In contrast to other multiple-launch rocket systems already in use, the TOS-1 was designed for close fire support at ranges of only 400 to 3,500 meters. As a result, an armored vehicle was used rather than an unarmored truck. Besides the BM-1 launcher vehicle, the system included a TZM resupply vehicle based on the KrAZ-255B truck. The system passed state trials and was accepted for Soviet Army use in 1980. It does not appear to have been widely manufactured and one Russian account puts

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1: BM-1/TOS-1A, AZERBAIJAN ARMY, BAKU, JUNE 2013

This is the color scheme painted on the BM-1/TOS-1A vehicles participating in the June 26, 2013 military parade in Baku marking the 95th anniversary of the Azerbaijani Armed Forces. The scheme was the same as that on the T-90A tanks, consisting of three principal colors of sand, dark green, and medium brown with a black disruptive pattern. No tactical markings were evident.

2: BM-1/TOS-1A, IRAQI ARMY, SIEGE OF MOSUL, 2016

Iraq acquired its TOS-1A during the fighting around Mosul and the vehicles were first used in that campaign. The vehicles were finished in Russian gray-yellow with a pattern of dark green and orange sand.

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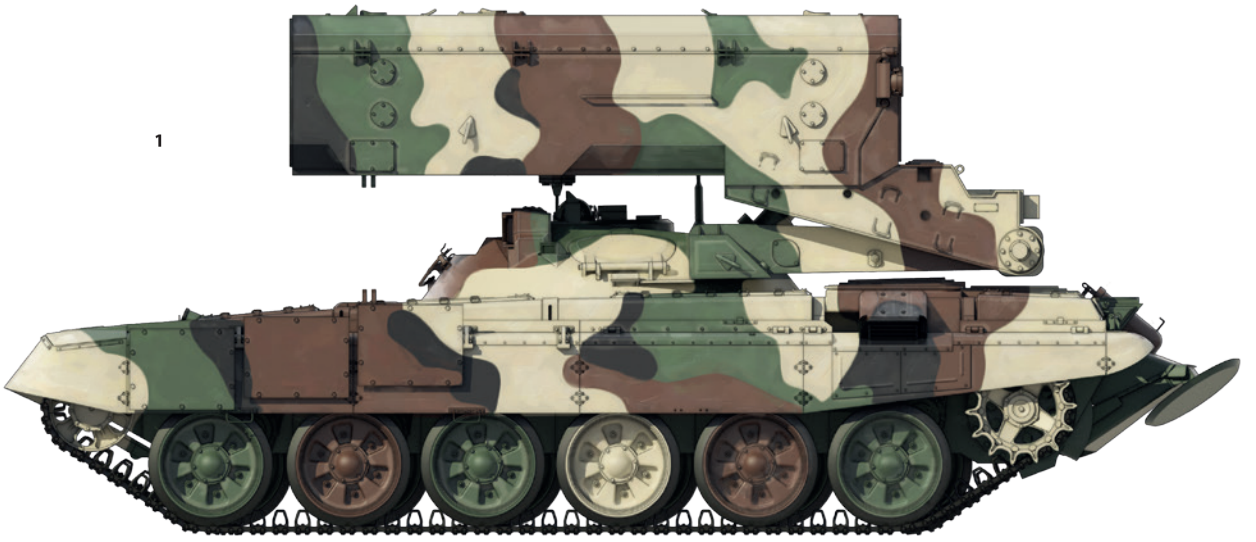

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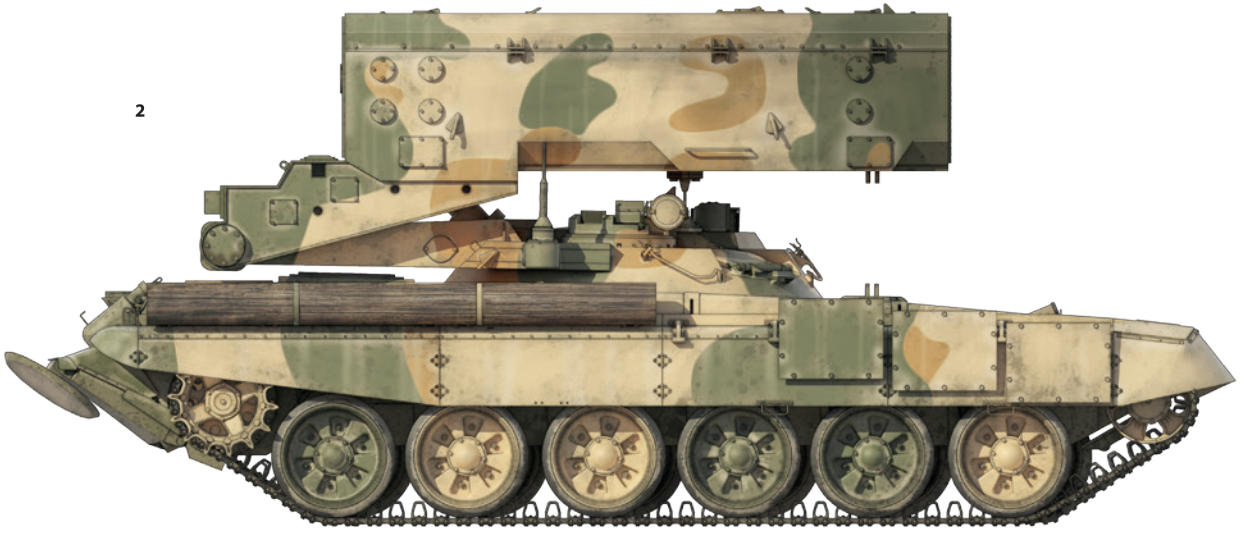

The BM-1 of the TOS-1A Solntsepyok system has a modified box launcher with only 24 rockets instead of the 30 rockets carried on the earlier TOS-1 Buratino system. This is a Russian Army example on display at the Army-2016 exhibition in Kubinka in September 2016.

production at only 18 vehicles. This was probably due to the fact that it was deployed by the specialized V-RKhBZ Radiological, Chemical, and Biological Defense Forces rather than the artillery branch.

Field trials of the TOS-1 Buratino took place during the Afghanistan War, when a battery of six BM-1 launchers plus support vehicles took part in the Panjshir valley fighting from 1988 to 1989. Following the Soviet collapse, remaining examples of the TOS-1 Buratino were reinducted into the Russian Army in 1995. They saw use in the fighting in the northern Caucasus, including the fighting for Grozniy in Chechnya in the late 1990s.

In the aftermath of the Chechen fighting, there was some interest in reviving the concept, and in 2000, the V-RKhBZ of the Russian Army sponsored a development project codenamed Solntsepyok (Sunburst) at Transmash in Omsk. The BM-1 launcher was reconfigured with cells for 24 instead of the previous 30 rockets. The rocket resupply vehicle was shifted from a truck to a T-72A (Obiekt 634B) chassis to permit the new TZM-T (Ob.563) to resupply the launcher closer to the front lines. Splav improved the rocket to extend its range to 6km.

The TOS-1A Solntsepyok was accepted for Russian Army service in 2003. It was subsequently offered for export and was initially sold to Azerbaijan and Kazakhstan in small numbers. Some were sold to Iraq in 2014, and a handful were transferred to the Syrian Army in 2016.

The TOS-1A Solntsepyok has seen scattered combat use. Its combat debut was with Iraqi forces during the recapture of Jurf al-Sakhar from ISIL on October 24, 2014. The Syrian Army has used them on a

A Russian Army BM-1 launch vehicle of the TOS-1A Solntsepyok system after a firing demonstration at the Alabino proving ground near Kubinka in September 2016.

The TZM-T reloading vehicle of the TOS-1A Solntsepyok carries 24 additional rockets and is fitted with a hydraulic crane to assist the process. It takes 24 minutes to reload the launcher vehicle. This example was displayed at the Russian Arms Exhibition near Nizhni-Tagil in September 2013. (Christopher Foss)

small scale in the civil war, starting in October 2015 near Hama. Azeri forces used them in the border skirmish with Armenia over the disputed Nagorno-Karabakh region on April 4, 2016 and at least one was lost in this fighting.

IMR-2M Engineer Vehicle

The IMR-2 engineer obstacle-clearing vehicle was originally developed on the T-72 chassis and manufactured at the Novokramatorsk plant. A total of 659 of these were manufactured through 1990. This vehicle was perhaps best known for its use during the efforts to deal with the Chernobyl nuclear power-plant disaster in 1986. When Ukraine separated from Russia in 1991, this left the Russian Army without a supply of these vehicles. As a result, UVZ reverse-engineered the design for local manufacture. This entered production in Nizhni-Tagil in 1990 as the IMR-2M. The IMR-2M has a variety of tools at its disposal for combat engineer tasks. The most prominent is a jib crane that can be extended up to 8 meters. It can be fitted with various tools, but is usually equipped with a clam-shell bucket device that can be used to hoist debris up to 2 metric tons or to pick up 0.35 meters of earth. In the front of the vehicle is a dozer/grader blade for clearing roads, filling trenches, and other tasks. There is also a set of mine rakes for mine-clearing at a speed of 5 to 12km/h.

The IMR-2M is a dedicated engineer combat vehicle for carrying out a multitude of tasks including obstacle removal, road clearing, and mine removal. It is fitted with a central crane with clam-shell lifting tool. In this view, the front dozer blade is in the transport position and folded up on the front of the hull. This example was displayed at the Urals Arms exhibition at the Staratel range outside Ekaterinburg in 2000.

An IMR-2M displaying its tools at the Staratel range near Yekaterinburg in 2000. The multipurpose clam-shell tool can be used for lifting obstacles as well as earthmoving.

The IMR-2M was also fitted with a EhMT electromagnetic mine detonation system for pre-empting the use of magnetically triggered mines. Besides being acquired for the Russian Army, some of the IMR-2M production was channeled to the MChS state emergency services. An improved version of the IMR-2M entered production in 1996 as the IMR-2MA with an enlarged superstructure for the crew. UVZ also manufactured the IMR-3M alongside the IMR-2M, with the basic difference being the use of the V-84MS power-pack from the T-72 tank. This version was built for the export market, since some countries were still ordering the T-72 tank that was less expensive than the T-90.

This IMR-2M was displayed at the Russian Arms Expo-13 near Nizhni-Tagil in September 2013. It shows the vehicle in travel mode with the dozer blade and mine rakes folded on the hull front. (Christopher Foss)

The BREM-1M was developed due to requests by export clients for a vehicle that could handle heavier loads with its crane. This example was displayed at the Army-16 show at Kubinka.

BREM-1M Armored Recovery Vehicle

The BREM-1M armored recovery vehicle was an upgrade to the earlier BREM-1 on the T-72 chassis. A total of 342 BREM-1 were manufactured up to 1990. The main incentive for this program was foreign interest by export clients such as India, which operated tanks other than Soviet/Russian types and wanted a heavier lift capacity for the hydraulic boom. The existing version had a 19 metric ton capacity and the new version was aimed at providing a 20–25 metric ton capacity, as well as increasing the recovery capacity from 100 metric tons of force to 140 metric tons. Aside from the switch to the V-92S2 engine, the crane was lengthened by one meter and the hydraulic system substantially reinforced. The BREM-1M was first displayed for export customers in 2002.

The MTU-90 was preceded in service by the MTU-72, which differ mainly in their power-plants. This MTU-72 is shown deploying its 20-meter steel bridge after having unfolded the front and rear sections.

The MTU-90M differs from the previous MTU-72 and MTU-90 in the configuration of its bridge, which was built in aluminum with scissors construction. This example was displayed at the Army-2016 exhibition at Kubinka.

MTU-90 Armored Bridge-layer

The MTU-90 bridge-layer was an improved version of the MTU-72 developed by the Omsk Transmash plant. This was a fairly rare vehicle with only 25 built in 1989 and 1990. The MTU-90 was essentially similar to the MTU-72 except for the use of T-90 compatible features such as the power-plant. Between 2007 and 2009, the Omsk plant examined future engineering needs under the Gusenitsa-3 research project. The main aim was to increase the carrying capacity of the bridge to handle future vehicles such as the new T-14 Armata tank that was under development at the time. The original bridge on the MTU-72 and MTU-90 was constructed from stamped aluminum and had two folding ramps at either end of the bridge. The new bridge uses steel construction and a scissors configuration, which increased its load capacity from 50 metric tons to 60 metric tons. This was accepted for production in 2012 as the MTU-90M.

The BRM-3M armored mine-clearing vehicle is fitted with the KMT-7 mine-clearing system that includes both mine rollers in front and mine rakes behind. The vehicle also has a 2.5-tonne (metric ton) crane and a 5-tonne cargo bed for tools. This example was displayed at the VTTV exhibition in 2000 at the Staratel proving ground near Ekaterinburg.

A BRM-3M mine clearing vehicle demonstrating its capabilities at the 2013 Russian Arms Exhibition near Nizhni-Tagil. The first BMR-3MA were delivered to the Russian army in the summer of 2017. (Christopher Foss)

BMR-3M Mine-Clearing Vehicle

The BMR-3M armored mine-clearing vehicle was yet another evolution of a combat engineer vehicle previously based on the T-72 chassis. The Obiekt 197 introduced the T-90 power-plant. The BMR-3M is intended to clear a path through minefields for tank columns. Its primary tool is the KMT-7 system, which includes both mine-rollers and mine rakes. The vehicle is also fitted with an electromagnetic device for prematurely detonating magnetically-activated mines. It also has a radio-frequency jammer for dealing with remotely-operated explosive devices such as improvised explosive devices (IEDs). It was first displayed in 1999, but as of 2016 none had been acquired by the Russian Army due to a lack of funding.

FURTHER READING

There is very little published material on the T-90 in English, although there is extensive coverage in Russian. Besides the small number of publications listed below, this book was based on articles that appeared in the Russian defense press, especially the magazine *Tekhnika i Vooruzhenie*. The author also relied on a large number of advertising brochures obtained while attending international arms shows since the early 1990s.

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Baranov, I. N., (ed.), *Glavniy konstruktor Vladimir Potkin: Tankoviy proryv* (Uralvagonzavod, 2013)

Ustyantsev, S., and D. Kolmakov, *T-72/T-90: Opyt sozdaniya otechestvennykh osnovnikh boyevikh tankov* (Uralvagonzavod, 2013)

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Glossary

APFSDS	Armor-piercing, fin-stabilized, discarding sabot (projectile)
AVSKU	*Apparatura vnutrenney svyazi, kommutatsii i upralvleniya*: External communications, connection and command device
BM	*Boyevaya mashina*: Combat vehicle
BMPT	*Boyevaya mashina poddershki tankov*: Tank support combat vehicle
BMR	*Bronirovannaya mashina razminirovaniya*: Armored mine-clearing vehicle
BREM	*Bronirovannaya remontno-evakyuatsionnaya mashina*: Armored recovery vehicle
ChTZ	*Chelyabinskiy traktorniy zavod*: Chelybinsk Tractor plant
GBTU	*Glavnoe bronetankovoe upravleniye*: Main Armored Vehicle Directorate
GLONASS	*Globalnaya navigatsionnaya sputnikovaya sistem*: Global satellite navigation system
HEAT	High-explosive, antitank (projectile)
IMR	*Inzhenernaya mashin razgrazhdeniya*: Engineer obstacle-clearing vehicle
MChS	*Ministerstvo po chrezvychaynim situatsiyam*: Ministry for Emergency Situations
MTU	*Mostukladchik*: Bridge-layer
NII	*Nauchno-ispitatelniy institut*: Scientific Research Institute
NIMI	*Nauchno-issledovatelskiy mashinostroilelniy institut*: Mechanical Engineering Research Institute, Moscow
Ob.	*Obrazets*: Model
Obiekt	Object, internal factory designation for armored vehicles
OKR	*Opitno-konstruktorskie roboty*: Experimental design study
PTK	*Programmno-tekhnicheskiy kompleks*: Digital computer
RHA	Rolled homogenous armor
RSZO	*Reaktivnaya sistema zalpovogo ogya*: Multiple-launch rocket system
SACLOS	Semi-active command-to-line-of-sight
SKB	*Spetsialnoe konstruktorskoe byuro*: Special Design Bureau
SUO	*Sistema upravleniya ognëm*: Fire-control system
TOS	*Tyazhelaya ognemetniy system*: Heavy flamethrower system
TsNII	*Tsentralnoe nauchno-ispitatelniy institut*: Central Scientific Research Institute
TZM	*Transportno-zaryazhayushchaya mashina*: Resupply vehicle
UDZ	*Universalno-dynamicheskaya zashchita*: Universal dynamic protection
UVZ	*Uralvagonzavod*: Urals Rail-car Plant, Nizhni-Tagil
V-RKhBZ	*Voisk radiatsionnoy, khimicheskoy i biologicheskoi zashchity*: Radiological, Chemical, and Biological Defense Forces
VTTV	*Voennaya tekhnika, tekhnologiya, vooruzhenie*: Military engineering, Technology, Armaments (Omsk military exhibition)
YeSU-TZ	*Yediniya system upravleniya takticheskogo zvena*: Unified command system for tactical units